CHAPTER 4.0 ELECTRIC TRANSMISSION

4.1 INTRODUCTION

This chapter describes in detail the transmission interconnection between the Kings River Conservation District Community Power Plant (KRCD CPP) and Pacific Gas and Electric Company (PG&E) McCall Substation, the existing electrical grid, and the anticipated impacts that the operation of the KRCD CPP will have on the flow of electrical power in the region. To better understand the impacts of the proposed KRCD CPP on transmission and power flows, the discussions in this chapter focus on those areas that allow a critical review of the electrical transmission and interconnection. More specifically, this analysis includes discussions of:

- The proposed electrical interconnection between the KRCD CPP and the electrical grid;
- The impacts of the electrical interconnection on the existing transmission grid;
- Potential nuisances (electrical effects, aviation safety, and fire hazards);
- Safety of the interconnection; and
- Description of applicable federal, state and local laws, ordinances, regulations, and standards (LORS).

4.2 TRANSMISSION INTERCONNECTION

The KRCD CPP is proposed as a nominal 565-megawatt (MW) net combined-cycle generating plant configured using two natural-gas-fired turbines and one steam turbine. KRCD has purchased the proposed project site, which is approximately 32-acres in size. The site is located in an area currently zoned for agriculture and is being used predominately for agricultural purposes (vineyards). Existing structures on the project site include a vacant rural dwelling, detached garage and barn. Approximately 15-acres of a 40-acre parcel to the immediate south of the project site will be used for temporary staging and parking during construction. A complete description of the KRCD CPP and associated linear facilities is included in Chapter 2, Project Description.

The KRCD CPP will connect to PG&E's electrical transmission system via a new 230 kilovolt (kV) radial transmission line running from the project site to the PG&E McCall Substation. The new electrical transmission line will be a 230-kV double circuit steel pole line utilizing aluminum conductor steel-reinforced (ACSR) 2156 thousand circular mils (kcmil) cable. The transmission line will proceed directly west from the project site across South Bethel Avenue for approximately one quarter mile, and then north approximately one mile across Manning Avenue. The line then proceeds directly west paralleling the south side of the existing PG&E McCall-Reedley 115-kV transmission line for approximately one mile. It then turns

northwesterly for approximately one quarter mile, crossing over the 115kV McCall-Reedley line and under the existing PG&E Balch-McCall and Hass-McCall 230kV lines. It then proceeds in a westerly direction for approximately two and one-half miles along Parlier Avenue to the McCall Substation located on Leonard Avenue. The proposed transmission line route is approximately five miles long. Figure 1-3 in Chapter 1, Executive Summary shows the location of the KRCD CPP and proposed interconnecting transmission line to the McCall Substation. Figure 2-11 in Chapter 2, Project Description shows the multiple existing transmission and distribution facilities currently located in the area of the KRCD CPP.

The electrical transmission line will cross both private property and public right-of-way. KRCD will negotiate with and secure necessary easements and approvals from private landowners prior to construction. KRCD will also obtain any necessary permits and approvals from public agencies for the crossings of South Bethel and Manning Avenues and from PG&E to cross their existing right-of-way.

Figure 4-1 is a schematic diagram of the major electric components of the proposed transmission interconnection, including the KRCD CPP generators, switchyard, generator tie lines and connection to the PG&E McCall Substation including additional bays, breakers and relocated breakers. This figure was provided by PG&E as part of the Interconnection System Impact Study Report (SIS). Figures 2-8 and 2-9 in Chapter 2, Project Description are one-line diagrams for the KRCD CPP switchyard showing the design and all major equipment required for interconnection of the generators with the switchyard, including bus duct connectors, switchgear, disconnect switches, generator step-up transformers, breakers and their respective ratings. More detailed McCall design drawings were requested from PG&E, including a one-line diagram for the substation before the interconnection of the KRCD CPP, and a one-line diagram for the substation after the addition of the KRCD CPP, showing all equipment ratings including breakers, disconnect switches, buses, and other equipment that is required for the addition of the project. Unfortunately, PG&E has responded that this level of detailed design drawing cannot be provided due to security reasons. Therefore, such detailed drawings are not included herein.

The capacity values shown for each generator in Figure 4-1 represent the rated gross capacity of each generator (total of 577-MW). Actual generation (565-MW) will be less than this rated capacity due primarily to parasitic loads.

4.3 TRANSMISSION LINES DESCRIPTION, DESIGN, AND OPERATION

The 230-kV line from the KRCD CPP project site to the McCall Substation will consist of two 230-kV circuits to be installed on double circuit steel pole structures ranging from 90 feet to 125 feet in height. An example of the standard pole design is included as Figure 4-2. The

transmission poles will be located in a 100 foot right-of-way. The proposed transmission line will also include two sets of two H-frame towers where the transmission line crosses under the existing PG&E Balch-McCall and Hass-McCall 230-kV lines and through the Manning recharge basin (see Section 8.16, Biological Resources and Appendix 8.16-3 Wetland and Waters Evaluation for information on the location of the recharge basin). The H-frame towers will be approximately 50 feet in height.

The line will be designed to National Electrical Safety Code (NESC) "Light" loading, and will consist of a single 2156 ACSR cable per phase (a total of six phase wires) in a "super bundle" (A-B-C/C-B-A) configuration to reduce electric and magnetic fields (EMF) at the edge of right-of-way. The transmission line will also be protected from lightning strikes by two 7/16 Extra High Strength static wires – one or both of which may be equipped with a fiber core for line protective relaying communications.

The KRCD CPP electric transmission line will be constructed, owned and operated by KRCD. The 230-kV breakers in the KRCD CPP switchyard (on the project site) will also be constructed, owned and operated by KRCD.

4.4 INTERCONNECTION FEASIBILITY STUDY

The California Independent System Operator (CAISO) completed an Interconnection Feasibility Study (IFS) for the KRCD CPP in January 2007. A copy of the IFS is included as Appendix 4-1. The IFS indicated that the project is technically feasible and can be reliably interconnected to the CAISO Controlled Grid if some network upgrades are completed prior to the project coming on line.

The IFS modeled the effects on the regional transmission system from the generation that will be added by the KRCD CPP. The IFS also assessed transmission system operation under stress after the addition of the project, for instance, assuming that one or more transmission system components are temporarily inoperable. Planning Criteria and Short-Circuit Duty Criteria for the IFS included the following:

- Line loading should not exceed 100 percent of a conductor's normal thermal rating with all facilities in service;
- Line loading should not exceed 100 percent of a conductor's emergency thermal rating with one line out of service (N-1); and
- Short-circuit duty should not exceed a circuit breaker's interrupting capability with maximum area generation on-line.

Potential KRCD CPP impacts in the IFS were assessed for the following load conditions:

- 2011 Summer Peak with one-in-ten loads in the Greater Fresno Area;
- 2011 Spring Peak with slightly reduced loads and high hydroelectric generation levels;
- 2011 Summer Off-Peak with loads at 50 percent of summer peak and Helms Pumped Storage at 620 MW of pumping load and Path 15 at 5000 MW; and
- 2011 Winter Peak with winter peak loads and the KRCD CPP at 614 MW.

The IFS concluded that, for the above noted summer and spring scenarios with the KRCD CPP and all other projects in the CAISO interconnection queue on-line, the addition of the KRCD CPP would:

- Cause a total of 8 new overloads with all lines in service (N-0);
- Cause a total of 18 new overloads for single (N-1) contingencies; and
- Cause a total of 25 new overloads for credible double contingencies (N-2).

The IFS also noted that:

- A total of 139 miles of 230-kV line, 54 miles of 115-kV lines, and 31 miles of 70-kV lines would need to be re-rated or reconductored in order to mitigate the overloads, and;
- A Facilities Study would be required to evaluate the need for circuit breaker replacements at the 115-kV, 230-kV, and 500-kV levels since, with the addition of the KRCD CPP, three-phase short-circuit duties and single line-to-ground short-circuit duties increased by 0.1 kilo amperes (kA) (or 100 amperes)) or more at several existing buses that have duty levels above 60 percent of their nameplate three-phase ratings.

The IFS also considered a case where a large generating project near the KRCD CPP with a higher CAISO queue position is not constructed. Calpine's proposed San Joaquin Valley Energy Center (SJVEC) was initially proposed as a 1,087 MW combined-cycle generating facility to be interconnected at PG&E's Helm substation near the City of San Joaquin, Fresno County. The SJVEC received a license from the CEC in January 2004, but has not yet been constructed. The SJVEC was downsized to a 791 MW rating in the CAISO interconnection queue in 2006. If the SJVEC is <u>not</u> constructed, the KRCD CPP impacts are reduced considerably, as follows:

- The KRCD CPP would cause only 1 new overload with all lines in service (N-0);
- The KRCD CPP would cause only 7 new overloads for single contingencies (N-1); and

- The KRCD CPP would cause only 14 new overloads for credible double contingencies (N-2).

The IFS concluded that mitigation of these overloads would require that only a total of 34 miles of 230-kV and 55 miles of 115-kV lines be re-rated or reconductored.

After the IFS was completed, a review meeting was held between KRCD, the CAISO and PG&E to discuss the results. During the IFS review meeting, it was noted that summer line ratings were inadvertently used by the CAISO for the winter study conditions. In addition, KRCD was informed that the Calpine SJVEC was downsized again to a rating of 660 MW. Finally, approximately 600 MW of other projects with higher queue positions had fallen from the queue since performance of the IFS. It was agreed that these changes would be made as part of the SIS. These changes would work to reduce resulting winter and summer overloads.

4.4 INTERCONNECTION SYSTEM IMPACT STUDY

The CAISO completed the SIS for the KRCD CPP in July 2007. A copy of the SIS is included as Appendix 4-2.

4.4.1 Scope of the System Impact Study

For the SIS, PG&E and the CAISO modeled the effects on the regional transmission system from the generation that would be added by the KRCD CPP in the year 2011. Steady-state power flow studies, short circuit studies, reactive power deficiency studies, dynamic stability studies and other assessments were performed. Specifically, the SIS:

- Identified transmission system impacts caused solely by the addition of the project,
- Identified system reinforcements necessary to mitigate the adverse impacts of the project under various system conditions,
- Provided the level of deliverability of the project by means of a Deliverability Assessment, and;
- Provided facilities required for system reinforcements with a non-binding good faith estimate of cost responsibility and a non-binding good faith estimate of time to construct these facilities.

4.4.2 Power Flow Study Criteria and Cases

For the SIS, the CAISO Controlled Grid Reliability Criteria, which incorporates the Western Electricity Coordinating Council (WECC) and the North American Electric Reliability Corporation (NERC) planning criteria, were used to evaluate the impact of the KRCD CPP on

the CAISO controlled grid. The criteria identifies a Normal Overload as one in which the loading of a transmission facility exceeds 100 percent of its normal rating. The loading of all transmission system facilities during normal system operation must be within their normal ratings. An Emergency Overload is where the loading of a facility exceeds 100 percent of its emergency rating. Emergency overloads can occur during single element contingencies (Category "B") and multiple element contingencies (Category "C").

Four power flow base cases were used to evaluate the feasibility of the proposed interconnection and the transmission system impacts of the KRCD CPP. While it is impractical to study all combinations of system load and generation levels during all seasons and at all times of the day, these four base cases represent extreme loading and generation conditions for the study area.

4.4.2.1 2011 Summer Peak Base Case

Power flow analyses were performed using PG&E's 2011 summer peak base case for the Greater Fresno area (in General Electric Power Flow format). This base case was developed from PG&E's 2006 base case series and has a 1-in-10 year extreme weather load level for the Greater Fresno area.

4.4.2.2 2011 Spring Peak Base Case

Power flow analyses were also performed using the 2011 spring base case for the Greater Fresno area to evaluate the potential congestion on transmission facilities under reduced load and increased hydro generation levels during a typical spring season. Hydro generation was modeled at a very high level as is typical in the spring season.

4.4.2.3 2011 Summer Off-Peak Base Case

Power flow analyses were also performed using the 2011 summer off-peak base case for the Greater Fresno area to evaluate potential congestion on transmission facilities during the off-peak system condition. The summer offpeak loads were modeled at approximately 50 percent of 2011 summer peak load level in the Greater Fresno area. Path 15 flows were modeled around 5,000 MW in a south-to-north direction. Two units at the Helms pumped storage plant (620 MW total) were assumed in pumping mode, and the Madera Unit was assumed to be generating at 28 MW.

4.4.2.4 2011 Winter Peak Base Case

Power flow analyses were performed using PG&E's 2011 winter peak base case for the Greater Fresno area to study the impacts of the KRCD CPP winter rating of 600 MW net output to the grid. This base case was developed from PG&E's 2006 base case series, and typical winter season peak load was applied in this base case.

4.4.2.5 Base Case and Sensitivity Case Analysis

PG&E and the CAISO performed these studies assuming that all of the proposed generation projects that are ahead of the KRCD CPP in the CAISO generator interconnection queue are in service. These generation projects are listed in Attachment 1 of Appendix A of the SIS (see Appendix 4-2). In addition, PG&E and the CAISO performed a "sensitivity" study, wherein the above studies were re-run assuming the proposed new 673 MW Calpine SJVEC does not achieve commercial operation. The SJVEC was initially proposed as a 1,087-MW combined-cycle generating facility to be located in the City of San Joaquin, Fresno County. The SJVEC received a license from the CEC in January 2004, but has not yet been constructed. The SJVEC was downsized to a 791-MW rating in the CAISO interconnection queue in 2006, and then downsized again to 673 MW in early 2007.

4.4.3 System Impact Study Results

Steady state power flow analyses reveals that interconnection of the KRCD CPP to the CAISO controlled grid would cause numerous normal and emergency overloads. A summary of these are provided in the Table 4-1 below.

Table 4-1
Summary of Forecast System Overloads after Addition of the KRCD CPP (Pre-Mitigation)
KRCD CPP

	Operation Condition						Sensitivity Study (without SJVEC)			
Overloads	**Normal**		**Category B**		**Category C**		**Normal**		**Category C**	
	New	**Pre-Project**	**New**	**Pre-Project**	**New**	**Pre-Project**	**New**	**Pre-Project**	**New**	**Pre-Project**
2011 Summer Peak Conditions	4	3	10	5	12	11	1	0	4	1
2011 Summer Off-Peak Conditions	6	1	14	2	16	14	0	0	2	0
2011 Spring Peak Conditions	8	1	14	8	21	13	N/A	N/A	N/A	N/A
2011 Winter Peak Conditions	0	0	6	0	8	5	N/A	N/A	N/A	N/A
N/A – not available										

However, reactive power study results revealed that addition of the KRCD CPP would cause no reactive power deficiencies. Dynamic stability study results revealed that addition of the KRCD CPP would cause no significant impact to the transient stability of the system. The substation evaluation found no overstressed breakers that would require mitigation due to addition of the

KRCD CPP. The Deliverability Assessment has not yet been completed by the CAISO and PG&E. Results are expected to be posted on the CAISO website soon.

4.4.3.1 Overload Mitigation

As part of the SIS, PG&E and the CAISO identified mitigation methods for Category "A" (normal) and "B" (single contingency) overloads. The CAISO preferred method to mitigate Category A and B overloads is to reconductor the overloaded lines with larger conductors. A summary of the specific facilities, identified mitigation and length of reconductorings is shown in Table 4-2 below.

Table 4-2
Summary of Recommended Mitigation and Reconductoring Mileage
KRCD CPP

Item	Description	With SJVEC			Without SJVEC		
		Worse Case	Reconductor		Worse Case	Reconductor	
		Overload	Mitigation	Miles	Overload	Mitigation	Miles
1	McCall-Sanger #1 115-kV				102%	Reconductor	6.50
2	McCall-Sanger #3 115-kV	128%	Reconductor	8.00			
3	Westley-Los Banos 230-kV				105%	Reconductor	34.00
4	Moss Landing-Coburn 230-kV	103%	Reconductor	26.00			
5	Tivy Valley-Reedley 70-kV				101%	Reconductor	13.00
6	Wilson-Le Grand 115-kV	114%	Reconductor	14.00			
7	Gates-McCall 230-kV (McCall–Henrietta Tap 2)	153%	Reconductor	41.00			
8	Kingsburg-Lemoore 70-kV (Hanford SW Sta-Hardwick-Kingsburg)	125%	Reconductor	16.00			
9	Kingsburg-Lemoore 70-kV (Hanford SW Sta-Lemoore)	143%	Reconductor	8.00			
10	Sanger-Reedley 70-kV (Sanger Jct-Parlier)	102%	Reconductor	12.00			
11	Barton-Sanger 115-kV (Airway Jct-Sanger)	115%	Reconductor	3.00			
12	Belota-Warnerville 230-kV	118%	Reconductor	.07			
13	Le Grand-Chowchilla 115-kV	118%	Reconductor	8.00			
14	Manchester-Sanger 115-kV	113%	Reconductor	11.50			
15	Mendota-San Joaquin 70-kV	128%	Reconductor	2.00			
16	Panoche-Dos Amigo 230-kV	105%	Reconductor	25.00			
17	Helm-Kerman 70-kV	109%	Reconductor	2.00			
18	Kearny-Kerman 70-kV	108%	Reconductor	11.00			
19	McCall-Kingsburg 115-kV #1		Replace switches				
20	Warnerville 230/115-kV Transformer Bank 1		Re-rate				
21	Warnerville 230/115-kV		Re-rate				

Table 4-2
Summary of Recommended Mitigation and Reconductoring Mileage
KRCD CPP

Item	Description	With SJVEC			Without SJVEC		
		Worse Case	Reconductor		Worse Case	Reconductor	
		Overload	Mitigation	Miles	Overload	Mitigation	Miles
	Transformer Bank 2						
22	Warnerville 230/115-kV Transformer Bank 3		Re-rate				
	Total			187.57			53.50

Reconductoring would require structural review of towers and/or poles to determine if a larger conductor can be supported. If the structures cannot support a larger conductor, consideration would be given to using a newer type ACSR cable that can tolerate operating temperatures up to 200 degrees Celsius (ºC) and thereby significantly increase the capacity of the line. The downside of this high temperature conductor is that higher line tension is required to allow for increased conductor sag. Higher line tensions or larger conductors may require re-building or replacement of dead-end and angle towers. Replacement of conductors and towers would result in some environmental impacts due to construction activities. However, the impacts should be significantly less than those associated with adding a new transmission line to previously undisturbed lands.

As an alternative to reconductoring, Category A and B overloads may be mitigated through re-rating (increased rating) of the transmission line. PG&E has stated that re-rating can be used to mitigate summer peak overloads on network lines only (limit to 20 percent). Re-rating of lines will entail site monitoring for wind conditions to determine if sufficient wind speeds can be relied on during summer peak load conditions to sufficiently cool the conductors and thereby obtain higher thermal ratings without sacrificing reliability due to conductor damage or safety due to increased sag of the conductors.

Category "C" (multiple contingency) overloads may be mitigated by load shedding or generation dropping. The CAISO or PG&E (or both) may require that KRCD participate in and pay the costs of special operating procedures and/or Special Protection Schemes (SPS) for Category C mitigation. The availability, scope and cost of this Category C mitigation will be determined in the CAISO Facilities Study.

As stated previously, PG&E has completed a SIS for the KRCD CPP. The study included three power flow base case conditions to evaluate the transmission system impacts of the project. The base case conditions took into account all approved PG&E transmission system projects and

planned generation facilities in the affected area (as identified in the CAISO Interconnection Queue). This list of projects is provided in the Study Plan located in Appendix A of the SIS (Appendix 4-2).

A sensitivity analysis was also included in the study in the event that the SJVEC and a proposed unnamed 300-MW project interconnecting at the McCall Substation does not occur. The results are included above in Table 4-2 and indicate that there are three overloads that are predicted and the overloads range from 101 to 105% of the line rating. The SJVEC project has been reconfigured in the CAISO study process on at least two occasions and the reconfigured plant has not been presented to the CEC for certification modification. Further, the unidentified 300-MW project interconnecting into the McCall Substation has not been proposed nor submitted to the CEC for licensing. For these reasons, KRCD believes that these projects will not take place or will take place after the KRCD CPP project and it is reasonable to assume the sensitivity study results.

Since the study was commenced, projects have been withdrawn of have been dropped from the CAISO Interconnection Queue that can affect these overloads. Also, it is anticipated that other projects will withdraw or will be dropped from the CAISO prior to commencement of the KRCD CPP Facilities Study and the three overloads identified in the sensitivity study will not occur. Further, given the relatively small degree of overload, actions other than reconductoring (including generation curtailment) may serve to mitigate the overload.

Based on these facts, KRCD believes that the Facilities Study will show that the project should not be responsible for reconductoring the three lines listed in the SIS and the environmental evaluation of the overloaded lines is not warranted at this time.

A reexamination of the overloads will take place in the CAISO Facilities Study and any required resulting environmental evaluation will be addressed if the Facilities Study shows that reconductoring is required.

4.6 TRANSMISSION LINE SAFETY AND NUISANCE

This section discusses safety and nuisance issues associated with the proposed electrical interconnection of the KRCD CPP with the electrical grid.

4.6.1 Electrical Clearances

Typical high-voltage overhead transmission lines are composed of bare conductors connected to supporting structures by means of porcelain or polymer insulators. The air surrounding the energized conductor acts as the insulating medium. Maintaining sufficient clearances, or air

space, around the conductors to protect the public and utility workers is paramount to the safe operation of the line. The safety clearance required around the conductors is determined by normal operating voltages, conductor temperatures, short-term abnormal voltages, wind-blown swinging conductors, contamination of the insulators, clearances for workers, and clearances for public safety. Minimum clearances are specified in CPUC General Order 95 (GO-95). Electric utilities, state regulators, and local ordinances may specify additional (more restrictive) clearances. Typically, clearances are specified for the following:

- Distance between the energized conductors themselves;
- Distance between the energized conductors and the supporting structure;
- Distance between the energized conductors and other power or communication wires on the same supporting structure; or between other power or communication wires above or below the conductors;
- Distance from the energized conductors to the ground and features such as roadways, railroads, driveways, parking lots, navigable waterways, airports, etc;
- Distance from the energized conductors to buildings and signs; and
- Distance from the energized conductors to other parallel power lines.

The proposed KRCD CPP transmission interconnection will be designed to meet all relevant national, state, and local code clearance requirements. The minimum ground clearance for 230-kV transmission line per the NESC is 22.4 feet, based on the road-crossing minimum. These are the design clearances for the maximum operating temperature of the line. Under normal conditions, the line operates well below maximum conductor temperature, and thus, the average clearance is much greater than the minimum. The final design clearances will be consistent with CPCU GO-95 and PG&E's guidelines for electric and magnetic field (EMF) reduction.

4.6.2 Electrical Effects

The electrical effects of high-voltage transmission lines fall into two broad categories: corona effects and field effects. Corona is the ionization of the air that occurs at the surface of the energized conductor and suspension hardware due to very high electric field strength at the surface of the metal during certain conditions. Corona may result in radio and television reception interference, audible noise, light, and production of ozone. Field effects are the voltages and currents that may be induced in nearby conducting objects.

4.6.2.1 Corona, Audible Noise, and Radio and Television Interference

Corona from a transmission line may result in the production of audible noise or radio and television interference. Corona is a function of the voltage of the line, the diameter of the

conductor, and the condition of the conductor and suspension hardware. The electric field gradient is the rate at which the electric field changes and is directly related to the line voltage. The electric field gradient is greatest at the surface of the conductor. Large-diameter conductors have lower electric field gradients at the conductor surface and, hence, lower corona than smaller conductors, everything else being equal. Also, irregularities (such as nicks and scrapes on the conductor surface) or sharp edges on suspension hardware concentrate the electric field at these locations and, thus, increase corona at these spots. Similarly, contamination on the conductor surface, such as dust or insects, can cause irregularities that are a source for corona. Raindrops, snow, fog, and condensation are also sources of irregularities.

Corona typically becomes a design concern for transmission lines having voltages of 345-kV and above. The KRCD CPP transmission line to McCall Substation is proposed as a 230-kV line, so no little corona effect is expected. The line will be designed to minimize corona noise by proper selection of the conductor and associated hardware. Interference complaints from the public can be investigated, and pre-and post construction surveys of levels can be performed. Noise created by any defective hardware or insulators can be mitigated to resolve the interference complaint.

4.6.2.2 Electric and Magnetic Fields

Operating power lines, like the energized components of electrical motors, home wiring, lighting, and all other electrical appliances, produce EMF. The EMF produced by the alternating current electrical power system in the United States has a frequency of 60 hertz (Hz), meaning that the intensity and orientation of the field changes 60 times per second.

Electric fields around transmission lines are produced by electrical charges on the energized conductor. Electric field strength is directly proportional to the line's voltage; that is, increased voltage produces a stronger electric field. At a given distance from the transmission line conductor, the electric field is inversely proportional to the distance from the conductors, so that the electric field strength declines as the distance from the conductor increases. The strength of the electric field is measured in units of kilovolts per meter (kV/m). The electric field around a transmission line remains steady and is not affected by the common daily and seasonal fluctuations in usage of electricity by customers.

Magnetic fields around transmission lines are produced by the level of current flow, measured in terms of amperes, through the conductors. The magnetic field strength is also directly proportional to the current; that is, increased amperes produce a stronger magnetic field. The magnetic field is inversely proportional to the distance from the conductors. Thus, like the electric field, the magnetic field strength declines as the distance from the conductor increases. Magnetic fields are expressed in units of milligauss (mG). The amperes and, therefore, the

magnetic field around a transmission line, fluctuate daily and seasonally as the usage of electricity varies.

Considerable research has been conducted over the last 30 years on the possible biological effects and human health effects from EMF. This research has produced many studies that offer no uniform conclusions about whether long-term exposure to EMF is harmful or not. In the absence of conclusive or evocative evidence, some states, California in particular, have chosen not to specify maximum acceptable levels of EMF. Instead, these states mandate a program of prudent avoidance whereby EMF exposure to the public will be minimized by encouraging electric utilities to use low-cost techniques to reduce the levels of EMF.

4.6.2.3 Electric and Magnetic Field Estimates

The EMF levels for the proposed KRCD CPP interconnection line have been estimated to determine if the line will cause any significant increase above current levels. The assumptions, methodology and results of this estimating are presented in this section.

Key Factors and Assumptions

EMF in the vicinity of power lines varies with line design, line loading, distance from the line, and other factors. EMF depends upon line voltage, which remains nearly constant for a transmission line during normal operation. EMF is also proportional to line loading (amperes) which varies as power plant generation is changed by the system operators to meet increases or decreases in electrical demand.

Another important parameter for these studies was the phase arrangement of the lines, both for the existing PG&E lines and the proposed KRCD CPP interconnection line. The phasing (i.e., relative location of A, B, and C phases) on a multi-circuit structure may offer some field cancellation, which results in reduced magnetic field values at the right-of-way edge. Studies have shown that cross-phasing double-circuit lines provides magnetic field reduction when both circuits are carrying power in the same direction. In cross-phasing, the circuit on one side of the structure is configured, for example, with phases A, B, and C arranged from top to bottom, while the other circuit is configured C, A, B from top to bottom.

EMF levels were calculated at specific points represented by the two cross-sections (A and B). Cross-section A represents the segments of the proposed line where it is not adjacent to other lines. This is the case for the majority of the line. Cross-section B represents the segment of the proposed line where it will parallel the existing PG&E 115-kV McCall-Reedley line. This is an approximately one and one-half mile segment running east-west between South Bethel and Del Rey avenues. This cross section was examined since EMF from the proposed KRCD CPP

transmission line may exacerbate existing EMF levels from the existing PG&E 115-kV McCall-Reedley line due to its proximity.

The electrical effects calculations are based on a 50-foot clearance for 230-kV lines. The generalized dimensions provided in the figures of this section should be regarded only as reference for EMF calculations and not absolute. The final design clearances will be consistent with CPUC GO-95 and PG&E's guidelines for EMF reduction.

Figure 4-3 is an elevation view of cross-section A. Figure 4-4 is an elevation view of cross-section B. The phasing configuration and conductor dimensions for the EMF studies are pictured.

Electric and Magnetic Field Calculations

EMF levels were calculated at a three feet elevation above flat terrain using the SCE FIELDS program. Measurement of EMF at three feet above the ground surface is in accordance with the Institute of Electrical and Electronic Engineers (IEEE) standards. FIELDS calculates the electric fields in kV/m and magnetic fields in mG. Inputs for the calculations include voltage, current load (ampheres), current angle (i.e., phasing), conductor type and spacing, number of subconductors, subconductor bundle symmetry, spatial coordinates of the conductors and shield wire, various labeling parameters, and other specifics. Field levels are calculated perpendicular to the line at the structure. For the calculations, the KRCD CPP transmission line was assumed to be loaded at 100 percent, which equates to an output level of 1000 amperes for the KRCD CPP with power being transmitted to McCall Substation.

Electric and Magnetic Field Results

Results of the EMF calculations are illustrated in the following figures:

- Figure 4-5 illustrates the estimated electric field (right axis) and magnetic field (left axis) for cross section A with the new KRCD CPP transmission line (post-project). This represents segments of the corridor that have only the new KRCD CPP transmission line. The centerline right-of-way is referenced to the centerline of the new 100-foot wide KRCD CPP transmission line right-of-way.
- Figure 4-6 illustrates the estimated electric field and magnetic field for cross-section B prior to addition of the KRCD CPP transmission line (for only the existing McCall-Reedley 115-kV line). The centerline right-of-way is referenced to the centerline of the combined new KRCD CPP transmission line and the existing McCall Reedley 115-kV right-of-way.

- Figure 4-7 illustrates the estimated electric and magnetic field levels for cross-section B including the new KRCD CPP 230-kV transmission line (post-project).

Summary of Electric and Magnetic Field Calculations

The majority of the proposed KRCD CPP transmission line corridor currently contains no existing transmission lines (cross-section A). The electric fields from these portions of the route are estimated to be less than 0.5-kV/m at either edge of the right-of-way. Magnetic field levels for this portion of the route are typical for a 230-kV double-circuit transmission line with a magnetic field of less than 40 mG at the left edge of the right-of-way (looking back towards the plant) and even less at the other edge.

The proposed 230-kV line will parallel an existing 115-kV line in cross-section B. Addition of the new KRCD CPP transmission line will increase the electric field level of the existing corridor from approximately 0.25-kV/m to approximately 0.29-kV/M at the right (southern) edge, and from approximately 0.10-kV/M to approximately 0.50-kV/m at the left (northern) edge. Similarly, magnetic field levels will increase from approximately 22 mG to 36 mG at the southern edge, and 4 mG to 40 mG at the northern edge.

Transmission Line EMF Reduction

While the State of California does not set a statutory limit for EMF levels, the CPUC, which regulates electric transmission lines, mandates EMF reduction as a practicable design criterion for new and upgraded electrical facilities. As a result of this mandate, the regulated electric utilities have developed their own design guidelines to reduce EMF at each new facility. The CEC, which regulates transmission lines to the point of connection, requires generators to follow the existing guidelines that are in use by local electric utilities or transmission-system owners.

In keeping with the goal of EMF reduction, the interconnection of the KRCD will be designed and constructed using the principles outlined in the PG&E publication, "EMF Design Guidelines for Electrical Facilities." These guidelines explicitly incorporate the directives of the CPUC by developing design procedures compliant with Decision 93-11-013 and GOs 95, 128, and 131-D. That is, when the transmission line structures, conductors, and rights-of-way are designed and routed according to the PG&E guidelines, the transmission line is consistent with the CPUC mandate. From the PG&E guidelines, the following magnetic reduction methods may be considered for new and upgraded electrical facilities:

- Increasing the distance from electrical facilities by:
  - Increasing structure height or trench depth; and
  - Locating power lines closer to the centerline of the corridor.
- Reducing conductor (phase) spacing; and
- Phasing circuits to reduce magnetic fields.

Anticipated EMF levels have been calculated for the KRCD CPP transmission line per the preliminary design as shown above. If required, the pre and post-interconnection verification measurements will be made consistent with IEEE guidelines and will provide sample readings of EMF at the edge of right-of-way. Additional measurements will be made upon request for locations of particular concern.

4.6.2.4 Electric Shock Hazards

A conducting object, such as a vehicle or person, in an electric field will experience induced voltages and currents. The strength of the induced current will depend upon the electric field strength, the size and shape of the conducting object, and the object-to-ground resistance. When a conducting object is isolated from the ground and a grounded person touches the object, a perceptible current or shock may occur as the current flows to ground. Industry-accepted design and construction techniques appropriate for mitigation of hazardous and nuisance shocks will be employed to ensure that metallic objects on or near the right-of-way are grounded and that sufficient clearances are provided at roadways and parking lots to keep electric fields at these locations low enough to prevent vehicle short-circuit currents from exceeding five milliamperes (mA).

Magnetic fields can also induce voltages and currents in conducting objects. Typically, this requires a long metallic object, such as a wire fence or aboveground pipeline that is grounded at only one location. A person who closes an electrical loop by grounding the object at a different location will experience a shock similar to that described above for an ungrounded object. Mitigation for this problem is to ensure multiple grounds on fences or pipelines, especially those that are orientated parallel to the transmission line.

As described elsewhere in this section, the proposed 230-kV interconnection lines will be constructed in conformance with CPUC GO-95 and Title 8 California Code of Regulation (CCR) 2700 requirements. Therefore, hazardous shocks are unlikely to occur as a result of KRCD CPP construction, operation, or maintenance.

4.6.2.5 Aviation Safety

Federal Aviation Administration (FAA) Regulations, Part 77 establishes standards for determining obstructions in navigable airspace and sets forth requirements for notification of proposed construction. These regulations require FAA notification for any construction over 200 feet in height above ground level. Notification is also required if the obstruction is lower than specified heights but falls within any restricted airspace in the approach to public or military airports. There are no airports or airport runways in the area of the proposed KRCD CPP. The closest airport is the Selma Airport located at 7225 Huntsman Avenue approximately one mile west of U.S. 99 or over two miles from the McCall Substation and almost five miles west of the project site. The proposed KRCD CPP transmission line is therefore not in the restricted space.

Since the new transmission towers will be less than 200 feet tall, and there are no public or military airports or heliports close enough to the project to trigger additional restrictions, an FAA air navigation hazard review will not be necessary. Further, there are a number of existing transmission lines and structures in the proximity that are taller or comparable in height. As a result of their location and height in relation to the above airfield, the structures of the proposed electrical transmission interconnection will pose no deterrent to aviation safety as defined in the FAA regulations.

4.6.2.6 Fire Hazards

The proposed 230-kV interconnection lines will be designed, constructed, and maintained in accordance with CPUC GOs that establish clearances from other natural and constructed structures as well as tree-trimming requirements to mitigate fire hazards. KRCD will use trained and qualified maintenance personnel to maintain the interconnection corridor and immediate area of the switchyard in accordance with accepted industry practices that will include recognition and abatement of any fire hazards.

4.7 APPLICABLE LAWS, ORDINANCES, REGULATIONS, AND STANDARDS

This section provides a list of applicable LORS that apply to the proposed transmission line, substations and engineering.

4.7.1 General Regulations

Table 4-3 lists the applicable general regulations that are applicable to the KRCD CPP.

Table 4-3 General Regulations KRCD CPP	
LORS	**Applicability**
GO-95, CPUC, "Rules for Overhead Electric Line Construction".	CPUC rule covers required clearances, grounding techniques, maintenance, and inspection requirements.
Title 8 CCR, Section 2700 et seq. "High Voltage Electrical Safety Orders".	Establishes essential requirements and minimum standards for installation, operation, and maintenance of electrical installation and equipment to provide practical safety and freedom from danger.
CPUC GO-52, "Construction and Operation of Power and Communication Lines".	Applies to the design of facilities to provide or mitigate inductive interference.
Fresno County Zoning Ordinance Section 875 (Public Utilities and Services).	Provides procedures to allow the County with a formal means of project review and comment and applies to all electric transmission facilities and electric utility facilities which are subject to either CPUC or CEC approval.

4.7.2 Design and Construction

Table 4-4 lists the applicable LORS for the general design and construction of the proposed electrical transmission line for the KRCD CPP.

Table 4-4 Design & Construction KRCD CPP	
LORS	**Applicability**
National Fire Protection Agency (NFPA) Section 70 – National Electric Code.	Recommends design and construction practices.
IEEE 1119, "IEEE Guide for Fence Safety Clearances in Electric-Supply Stations".	Recommends clearance practices to protect persons outside the facility from electric shock.
IEEE 998, "Direct Lightning Strike Shielding of Substations.	Recommends protections for electrical system from direct lightning strikes.
IEEE 980, "Containment of Oil Spills for Substations".	Recommends preventions for release of fluids into the environment.
PG&E Standards –Electric Design Standard Book , Protection Standard Design Book 2, Civil Design Standard Book 3, Engineering Standard Book 4, Overhead Construction Manual, Substation Maintenance and Construction Manual and Substation Standards, Guidelines, and Information Bulletin Handbook.	Provides guidelines for the design and construction of facilities that will interconnect to the PG&E system.

4.7.3 Electric and Magnetic Fields

The applicable LORS pertaining to EMF interference are tabulated in Table 4-5.

Table 4-5
Electric and Magnetic Fields
KRCD CPP

LORS	Applicability
Decision 93-11-013, CPUC.	CPUC position on EMF reduction.
GO-131-D, CPUC, "Rules for Planning and Construction of Electric Generation, Line, and Substation Facilities in California".	CPUC construction application requirements, including requirements related to EMF reduction.
American National Standards Institute (ANSI)/IEEE 644-1994, "Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines".	Standard procedure for measuring EMF from an electric line that is in service.
PG&E "EMF Guidelines of New Electrical Facilities: Transmission, Substation and Distribution".	Includes procedures under which a facility must be designed in consideration of appropriate EMF mitigation measures.

4.7.4 Hazardous Shock

Table 4-6 lists the LORS regarding hazardous shock protection that are applicable to the KRCD CPP.

Table 4-6
Hazardous Shock
KRCD CPP

LORS	Applicability
8 CCR 2700 et seq. "High Voltage Electrical Safety Orders".	Establishes essential requirements and minimum standards for installation, operation, and maintenance of electrical equipment to provide practical safety and freedom from danger.
ANSI/IEEE 80, "IEEE Guide for Safety in AC Substation Grounding".	Presents guidelines for assuring safety through proper grounding of alternating current outdoor substations.
NESC, ANSI C2, Section 9, Article 92, Paragraph E; Article 93, Paragraph C.	Covers grounding methods for electrical supply and communications facilities.
PG&E Substation Maintenance and Construction Manual, Guidelines & Information Bulletin Handbook and Electric Overhead Construction Manual.	Includes procedures with which a facility must comply to provide protection against hazardous shock.

4.7.5 Communications Interference

Table 4-7 lists the LORS regarding communication interference are applicable to the KRCD CPP.

Table 4-7
Communications Interference
KRCD CPP

LORS	Applicability
47 Code of Federal Regulations (CFR) 15.25, "Operating Requirements, Incidental Radiation".	Prohibits operations of any device emitting incidental radiation that causes interference to communication; the regulation also requires mitigation for any device that causes interference.
CPUC GO 52.	Covers all aspects of the construction, operation, and maintenance of power and communication lines and specifically applies to the prevention of mitigation of inductive interference.

4.7.6 Aviation Safety

Table 4-8 lists the aviation safety LORS that are applicable to the proposed KRCD CPP.

Table 4-8
Aviation Safety
KRCD CPP

LORS	Applicability
Title 14 CFR, FAA Regulations Part 77, "Objects Affecting Navigable Airspace".	Describes the criteria used to determine whether a "Notice of Proposed Construction or Alteration" (FAA Form 7460-1) is required for potential obstruction hazards.
FAA Advisory Circular No. 70/7460-1G, "Obstruction Marking and Lighting".	Describes the FAA standards for marking and lighting of obstructions as identified by FAA Regulations Part 77.
CPUC, Sections 21656-21660.	Discusses the permit requirements for construction of possible obstructions in the vicinity of aircraft landing areas, in navigable airspace, and near the boundary of airports.

4.7.7 Fire Hazards

Table 4-9 lists the fire hazard LORS that are applicable to the proposed KRCD CPP.

Table 4-9
Fire Hazards
KRCD CPP

LORS	Applicability
14 CCR Sections 1250-1258, "Fire Prevention Standards for Electric Utilities".	Provides specific exemptions from electric pole and tower firebreak and electric conductor clearance standards, and specifies when and where standards apply.
ANSI/IEEE 80, "IEEE Guide for Safety in Alternating Current Substation Grounding".	Presents guidelines for assuring safety through proper grounding of AC outdoor substations.
CPUC GO-95, "Rules for Overhead Electric Line Construction," Section 35.	CPUC rule covers all aspects of design, construction, operation, and maintenance of electrical transmission line and fire safety (hazards).
PG&E Substation Maintenance and Construction Manual, Guidelines & Information Bulletin Handbook and Electric Overhead Construction Manual.	Includes procedures with which a facility must comply to provide protection against fire hazards.

4.8 INVOLVED AGENCIES AND CONTACTS

Table 4-10 identifies applicable agencies with jurisdiction to issue permits or approvals, conduct inspections, and/or enforce the above-referenced LORS. Table 4-10 also identifies the associated responsibilities of these agencies as they relate to the construction and operation and maintenance of the proposed KRCD CPP.

Table 4-10
List of Agency Contacts
KRCD CPP

Agency	Responsibility
FAA	Establishes regulations for marking and lighting of obstructions in navigable airspace (No. 70/7460-1G).
Local Electrical Inspector	Jurisdiction over safety inspection of electrical installations that connect to the supply of electricity (NFPA Section 70).
Fresno County	Establishes and enforces zoning regulations for specific land uses. Issues variances in accordance with zoning ordinances. Issues and enforces certain ordinances and regulations concerning fire prevention and electrical inspection.

4.9 REFERENCES

CAISO . 2007a. Interconnection Feasibility Study Report – Generation Interconnection Revision #2. For the Kings River Conservation District Community Power Plant. January 19, 2007.

CAISO. 2007b. Interconnection System Impact Study Plan – Generation Interconnection Revision #2. For the Kings River Conservation District Community Power Plant. March 6, 2007.

CAISO. 2007c. Interconnection System Impact Study Report. For the Kings River Conservation District Community Power Plant. July 30, 2007.