EMF Design Guidelines for Electrical Facilities

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Table of Contents

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1 California EMF Policy

1.1 Historical Background of California EMF Policy

In 1993, the California Public Utilities Commission (CPUC) issued Decision 93-11-013, establishing EMF policy for California's regulated electric utilities.

The Decision acknowledged that scientific research had not demonstrated that exposures to EMF cause health hazards and that it was inappropriate to set numeric standards that would limit exposure. In recognizing the scientific uncertainty, the CPUC addressed public concern over EMF by establishing a no-cost and low-cost EMF reduction policy that utilities would follow for proposed electrical facilities.

In workshops ordered by the CPUC, the utilities developed the initial EMF Design Guidelines based upon the no-cost and low-cost EMF policy. Fundamental elements of the policy and the Design Guidelines included the following:

A) No-cost and low-cost magnetic field reduction measures would be considered on new and upgraded projects.

B) Low-cost measures, in aggregate, would:

   a. Cost in the range of 4% of the total project cost.

   b. Achieve a noticeable magnetic field reduction.

   The CPUC stated,

   > "We direct the utilities to use 4 percent as a benchmark in developing their EMF mitigation guidelines. We will not establish 4 percent as an absolute cap at this time because we do not want to arbitrarily eliminate a potential measure that might be available but costs more than the 4 percent figure. Conversely, the utilities are encouraged to use effective measures that cost less than 4 percent."[1]

C) For distribution facilities, utilities would apply no-cost and low-cost measures by integrating reduction measures into construction and design standards, rather than evaluating no-cost and low-cost measures for each project.

1.2 Current California EMF Policy

In 2006, the CPUC updated its EMF Policy in Decision 06-01-042. The decision re-affirmed that health hazards from exposures to EMF have not been established and that state and federal public health regulatory agencies have determined that setting numeric exposure limits is not appropriate. The CPUC also re-affirmed that the existing no-cost and low-cost precautionary-

[1] CPUC Decision 93-11-013, Section 3.3.2, p.10

based EMF policy should be continued. In the decision, the CPUC required the utilities to update their EMF Design Guidelines to reflect the following key elements of the updated EMF Policy:

A) "The Commission [CPUC] has exclusive jurisdiction over issues related to EMF exposure from regulated utility facilities."[2]

B) "…while we continue our current policy of low-cost and no cost EMF mitigation, as defined by a 4% benchmark of total project cost, we would consider minor increases above the 4% benchmark if justified under unique circumstances, but not as a routine application in utility design guidelines. We add the additional distinction that any EMF mitigation cost increases above the 4% benchmark should result in significant EMF mitigation to be justified, and the total costs should be relatively low."[3]

C) For low cost mitigation, the "EMF reductions will be 15% or greater at the utility ROW [right-of-way]…"[4]

D) "Parties generally agree on the following group prioritization for land use categories in determining how mitigation costs will be applied:

1. Schools and licensed day care[5]
2. Residential
3. Commercial/industrial
4. Recreational
5. Agricultural
6. Undeveloped land"

E) "Low-cost EMF mitigation is not necessary in agricultural and undeveloped land except for permanently occupied residences, schools or hospitals located on these lands."[6]

F) "Although equal mitigation for an entire class is a desirable goal, we will not limit the spending of EMF mitigation to zero on the basis that not all class members can benefit."[7]

G) "…. We [CPUC] do not request that utilities include non-routine mitigation measures, or other mitigation measures that are based on numeric values of EMF exposure, in revised design guidelines…"[8]

[2] CPUC Decision 06-01-042, p. 21
[3] Ibid., p. 7
[4] Ibid., p. 10
[5] "As an additional fixed location of young children, we will add hospitals to this category." Ibid., p. 7
[6] Ibid., p. 20
[7] Ibid., p. 10
[8] Ibid., p. 17

The CPUC also clarified utilities' roles on EMF during the CPCN (Certificate of Public Convenience and Necessity) and PTC (Permit to Construct). The CPUC stated,

> "EMF concerns in future CPCN [Certificate of Public Convenience and Necessity] and PTC [Permit to Construct] proceedings for electric transmission and substation facilities should be limited to the utility's compliance with the Commission's [CPUC] low-cost and no-cost policies."[9]

Furthermore, the CPUC directed "the Commission's Energy Division to monitor and report on new EMF related scientific data as it becomes available."[10] These EMF Design Guidelines, therefore, will be revised as more information or direction from the CPUC becomes available.

1.2.1 Standardized EMF Design Guidelines

Decision 06-01-042 directed the utilities to hold a workshop to develop standard approaches for their EMF Design Guidelines. This workshop was held in spring of 2006, and this document represents the standardized design guidelines produced as a result of that workshop. The guidelines describe the routine magnetic field reduction measures that all regulated California electric utilities will consider for new and upgraded transmission line and transmission substation projects.

These guidelines are not applied to changes made in connection with routine maintenance, emergency repairs, or minor changes to existing facilities. See §3.4 for a list of exemptions.

1.2.2 Standardized Table of Magnetic Field Reduction Measures

As directed by Decision 06-01-042, these guidelines include a standardized table that utilities will use to summarize "the estimated costs and reasons for adoption or rejection"[11] of reduction measures considered for any particular project. Table 1-1 shows the information to be displayed in the standardized table. Utilities may choose to add columns for additional information as necessary for any particular project. Typical format is shown below.

Table 1-1 Low-Cost Reduction Measures Adopted or Rejected

Project Segment	Location (Street, Area)	Adjacent Land Use	Reduction Measure Considered	Measure Adopted? (Yes/No)	Reason(s) if not adopted	Estimated Cost to Adopt
		Per §1.2-D	Per § 2			

[9] Ibid., p. 21
[10] Ibid., p. 16
[11] Ibid., p. 13.

1.2.3 Additional Considerations Used in the Design Guidelines

These additional elements of policy resulting from Decisions 93-11-013 and 06-01-042 are fundamental to application of the guidelines:

- Any proposed changes in guidelines should be consistent with the EMF policy established in this decision [D.06-01-042] and in D.93-11-013.[12]
- The guidelines "should not compromise safety, reliability, or the requirements of [CPUC] General Orders (GO) 95 and 128."[13]
- Without exception, design and construction of electric power system facilities must comply with all applicable federal and state regulations, applicable safety codes, and each electric utility's construction standards.
- Non-routine field reduction measures are not necessary except in unique circumstances, and are not included in the guidelines.
- The guidelines do not include reduction measures "that are based on numeric values of EMF exposure."[14]
- Modeling is done for magnetic fields only.
- Modeling of magnetic fields is for comparison of reduction techniques, and "does not measure actual environmental magnetic fields."[15]
- "[P]ost-construction measurement of EMF in the field cannot indicate the effectiveness of mitigation measures"[16] and is not required.
- "The appropriate location for measuring EMF mitigation is the utility ROW as this is the location at which utilities may maintain access control."[17]
- Reduction measures are not applicable to reconfigurations or relocations of up to 2,000 feet, the distance under which certain exemptions apply under GO 131-D.[18]
- "Utility design guidelines should consider EMF mitigation at the time the FMP [(Magnetic) Field Management Plan] is prepared…" The CPUC does "not require utility design guidelines to include low-cost EMF mitigation for undeveloped land."[19]
- Distribution facilities are not considered in magnetic field modeling or in FMPs for transmission line or substation projects rated 50 kV and above.

[12] Ibid., p. 20.
[13] Ibid., p. 21.
[14] Ibid., p. 17.
[15] Ibid., p. 11.
[16] Ibid., p. 11.
[17] Ibid., p. 20.
[18] The CPUC's General Order 131-D establishes rules and specifications for permitting and construction of electric generation, transmission and distribution facilities and substations located in California.

[19] Ibid., p. 9.

2 Methods for Reducing Magnetic Fields

The following magnetic field reduction methods may be considered for new and upgraded electrical facilities:

A) Increasing the distance from electrical facilities by:
   a. Increasing structure height or trench depth.
   b. Locating power lines closer to the centerline of the corridor.

B) Reducing conductor (phase) spacing.

C) Phasing circuits to reduce magnetic fields.

2.1 Increasing the Distance from Electrical Facilities

Reducing magnetic field strength by increasing the distance from the source can be accomplished either by increasing the height or depth of the conductor from ground level. Furthermore, locating the power lines as far away from the edge of the right-of-way or as close to centerline as possible will result in lower field levels at the edge of the right-of-way. For substations, placing major electrical equipment, such as switch-racks and power transformers, near the center of the substation can reduce the magnetic field levels at the property line.

2.2 Reducing Conductor (Phase) Spacing

The magnetic field produced by overhead and underground power lines is approximately inversely proportional to the distance between the phase conductors. Thus, reducing the spacing between conductors by 50 percent generally reduces the magnetic field at ground level by approximately 50 percent. The minimum distance between overhead conductors for power lines built in California is established by CPUC General Order (GO) 95. Utilities may establish minimum clearances greater than those allowed in GO 95 if required for safe working conditions or to prevent flash over. In most cases, insulation levels will be established based on lightning, switching surge, or insulator contamination considerations.

Because underground conductors are insulated, they may be placed within inches of each other. This means that there generally can be greater magnetic field cancellation in an underground circuit than an overhead circuit. Therefore, the magnetic field levels from an underground circuit will generally be lower than a comparably loaded overhead circuit at most locations other than directly above the underground line, where the cancellation effect of the underground conductors is offset by their proximity to the surface. In contrast, overhead conductors will be much farther away and will generally create a lower magnetic field directly under the line than a comparably loaded underground circuit.

2.3 Phasing Circuits to Reduce Magnetic Fields

When two or more circuits share a pole or tower, the resultant magnetic field will be the vector sum of the individual conductor fields on the structure. By using proper phasing techniques, the field from one circuit can reduce the field from another circuit, thereby reducing the level of magnetic field at ground level.

3 The Field Management Plan Process

3.1 The Field Management Plan

The Field Management Plan (FMP) documents the consideration of no-cost and low-cost magnetic field reduction measures for new or significantly reconstructed transmission lines and substations rated 50 kV and above (refer to § 3.4 for exceptions).

FMPs will be prepared for relevant transmission projects and will be retained with the work order. For any project requiring a permit under GO 131-D, the FMP will be incorporated as a part of the GO 131-D filing.

Utilities have incorporated magnetic field reduction measures into their distribution construction and design standards. Therefore, FMPs are not prepared for any distribution projects.

Basic elements of the FMP include a project description, an evaluation of no-cost and low-cost magnetic field reduction measures, and specific recommendations regarding magnetic field reduction measures to be incorporated into the transmission line and substation design (see §§ 4 and 5 of these guidelines for additional information concerning the contents of transmission line and substation FMPs).

3.2 Types of FMP

There are two types of FMP for transmission line projects, a "Basic FMP" and a "Detailed FMP," and a "Checklist FMP" for substation projects.

For transmission line projects with limited work scope, as described in Table 3-1 below, a Basic FMP is sufficient to document no-cost and low-cost magnetic field reduction measures. The Basic FMP consists of a transmission line project description, applicable no-cost and low-cost magnetic field reduction measures without magnetic field model(s), and recommendations.

The Detailed FMP consists of a transmission line project description, evaluation of no-cost and low-cost magnetic field reduction measures, magnetic field models, and recommendations (refer to § 3.3 to determine what types of transmission line projects require a Detailed FMP).

For substation projects, a checklist FMP, showing an evaluation of magnetic field reduction measures adopted or rejected, will be used. An example of the Checklist FMP is shown on Table 5-1.

3.3 Determining If an FMP is Required, and If so, What Type

The CPUC in Decision 93-11-013 (§ 3.4.2, p. 15) states, "Utility management should have reasonable latitude to deviate and modify their guidelines as conditions warrant and as new magnetic fields information is received." Table 3-1 provides criteria to determine if the project requires a Detailed FMP, a Basic FMP, a Checklist FMP, or no FMP.

Table 3-1 Criteria to Determine Whether an FMP is Required		
FMP Type Required	**Type of Work**	**FMP Criteria**
Transmission Line (rated 50 kV and above)		
Detailed FMP Note: A Detailed FMP will be used for transmission line projects requiring permitting under GO 131-D.	**New Transmission Line**: The construction of a new transmission line, if the construction requires permitting under GO 131-D. **Major Upgrade**: Major upgrade (including replacement of a significant number of existing structures) on an existing transmission line, if the upgrade requires permitting under GO 131-D.	The construction of a new transmission line will incorporate no-cost and low-cost magnetic field reduction measures. Magnetic field model is required. All major upgrades of existing transmission lines will require no-cost and low-cost magnetic field reduction measures unless otherwise exempted under § 3.4. If permitting under GO 131-D is not required, a Basic FMP may be used, and magnetic field modeling is not required.
Basic FMP Note: A Basic FMP will be used unless the transmission line project requires permitting under GO 131-D.	**Rule 20 Conversions**: Direct replacement of overhead transmission lines with underground transmission lines under Rule 20. **Relocation more than 2000 ft**: Relocation of poles and/or towers involving more than 2000 feet of transmission line. **Pole-head Reconfiguration more than 2000 ft**: Pole-head reconfiguration involving more than 2000 feet of transmission line. The complete replacement of an existing pole-head configuration with a new design.	The transmission line route generally is pre-established for Rule 20 conversions. Phase spacing and depth are set by utility construction standards. Thus, phase arrangement is the only magnetic field reduction measure available to the designer. Therefore, the Basic FMP will be restricted to an evaluation of phase arrangement. Magnetic field modeling is not required. Relocation of existing transmission lines generally does not provide for alternative transmission line routes. Available options are typically limited to minor changes in pole and/or tower height, minor changes in pole-head[20] configuration, or phase arrangement. The Basic FMP will normally cover these options only. Magnetic field modeling is not required. Pole-head replacement is limited in scope; thus, field management options are generally restricted to selecting the pole-head configuration and phase arrangement. In most cases, the new pole-head configuration must be consistent with the remainder of the line. The Basic FMP will be limited to an

[20] It can also be referred to as "pole-top"

Table 3-1 Criteria to Determine Whether an FMP is Required		
FMP Type Required	**Type of Work**	**FMP Criteria**
Basic FMP Note: A Basic FMP will be used unless the transmission line project requires permitting under GO 131-D	 **Reconductoring more than 2000 ft.**: Replacement only of existing conductors and/or insulators with new conductors and/or insulators.	assessment of alternative pole-head configurations and will not require magnetic field modeling. In most cases, replacement of existing transmission conductors is limited in scope; therefore, the Basic FMP will be limited to an assessment of phase arrangement for reconductor activity involving more than 2000 transmission circuit feet. Magnetic field modeling is not required.
None (see exemptions § 3.4)	**Relocation less than 2000 ft**: Relocation of poles and/or towers involving less than 2000 feet of transmission line(s). **Reconductoring less than 2000 ft.**: Replacement only of existing conductors and/or insulators with new conductors and/or insulators. **Pole-head Re-Configuration less than 2000 ft.:** Pole-head reconfiguration involving 2000 feet or less of a transmission line(s) will not require a FMP. **Maintenance:** All maintenance work that does not materially change the design or overall capacity of the transmission line, including the one-for-one replacement of hardware, equipment, poles or towers. **Safety and Protective Devices:** The addition of current transformers, potential transformers, switches, power factor correction, fuses, etc. to existing overhead, pad-mount, or underground circuits. **Emergency Repairs:** All emergency work required to restore service or prevent danger to life and property.	Minor relocation of facilities is limited in scope and does not provide significant opportunity to implement magnetic field reduction measures. Replacement of existing transmission line conductors is limited in scope and does not provide significant opportunity to implement magnetic field reduction measures. Pole-head reconfiguration involving 2000 feet or less of a transmission line(s) will not require a FMP. Maintenance work is limited in scope and does not provide significant opportunity to implement magnetic field reduction measures. The addition of protective equipment or power factor correction to existing transmission circuits is limited in scope and does not provide significant opportunity to implement magnetic field reduction measures. This work is performed on existing facilities under emergency conditions and does not involve redesign.

Table 3-1 Criteria to Determine Whether an FMP is Required		
FMP Type Required	**Type of Work**	**FMP Criteria**
Substation (Rated 50 kV and above)		
Checklist FMP	**New Substations:** The construction of a new substation having a rated high side voltage of 50kV or above.	The construction of a new substation will incorporate no-cost and low-cost magnetic field reduction measures as outlined in §5. A no-cost and low-cost checklist[21] will be used as a part of the FMP.
	Major Upgrade with GO 131-D: Major reconstruction of an existing substation that involves the installation of additional transformers to achieve an increased rated capacity and that requires permitting under GO 131-D.	All major upgrade of existing substations will require evaluations of no-cost and low-cost magnetic field reduction measures as outlined in §5, unless otherwise exempted under § 3.4. A no-cost and low-cost check list may be used.
	Major Upgrade without GO 131-D: Major upgrade of an existing substation that involves the installation of additional transformers to achieve an increased rated capacity and that does not require permitting under GO 131-D.	Major substation upgrade projects involving the addition of new transformers but not requiring GO 131-D permitting may use a no-cost and low-cost check list only. The 'no-cost and low-cost' will be limited to an evaluation of magnetic field reduction measures applicable to the transmission get-away[22] and to the location of the new transformers so as to maximize the distance from the transformers to the substation fence.

[21] See Section 5 for more information about no-cost and low-cost check lists for substation projects.
[22] This can be a part of Transmission FMP.

Table 3-1 Criteria to Determine Whether an FMP is Required		
FMP Type Required	**Type of Work**	**FMP Criteria**
None (see exemptions § 3.4)	**Reconstruction without installation of additional transformers**: This includes, for example, the installation of additional switchgear, line or bank positions, power factor correction capacitors, underground circuits and overhead circuits.	The addition of switchgear or other apparatus is limited in scope and does not provide significant opportunity to implement magnetic field reduction measures.
	Direct Replacement: The direct replacement of substation equipment, even if the new equipment has a different capacity rating.	The direct replacement of substation equipment is limited in scope and does not provide significant opportunity to implement magnetic field reduction measures.
	Maintenance: All maintenance work that does not materially change the design of the substation.	Maintenance work is limited in scope and does not provide significant opportunity to implement magnetic field reduction measures.
	Emergency Repairs: All emergency work required to restore service or prevent danger to life and property.	This work is performed on existing facilities under emergency conditions and does not involve redesign.
Distribution Project (Rated less than 50 kV)		
None	Construction or reconstruction of distribution lines with voltages less than 50 kV.	Each electric utility's distribution construction and design standards incorporates magnetic field reduction measures for distribution lines.

3.4 Projects Exempt from the FMP Requirement

The CPUC, in Decision 93-11-013, recognized that some flexibility was required in the EMF Design Guidelines. In section 3.4.2 of the Decision, the CPUC stated: "Electric utility management should have flexibility to modify the guidelines and to incorporate additional concepts and criteria as new EMF information becomes available. However, if the EMF Design Guidelines are to be truly used as guidelines, the utilities should incorporate criteria which justify exempting specific types of projects from the guidelines."

The following criteria to determine those transmission and substation projects exempted from the requirement for consideration of no-cost and low-cost magnetic field reduction measures:

1. Emergency
   - All work required to restore service or remove an unsafe condition.
2. Operation & Maintenance
   - Washing and switching operations.
   - Replacing cross-arms, insulators, or line hardware.
   - Replacing deteriorated poles.
   - Maintaining underground cable and vaults.
   - Replacing line and substation equipment with equipment serving the same purpose and with similar ratings.
   - Repairing line and substation equipment.
3. Relocations
   - Line relocation of up to 2000 feet.
   - Installation of guy poles or trenching poles only.
4. Minor Improvements
   - Addition of safety devices.
   - Reconductoring up to 2000 feet, where changing pole-head configuration is not required.
   - Installation of overhead switches.
   - Insulator replacement.
   - Modification of protective equipment and monitoring equipment.
   - Intersetting of additional structures between existing support structures.
5. Projects located exclusively adjacent to undeveloped land—including land under the jurisdiction of the National Park Service, the State Department of Parks and Recreation, U.S. Forest Service, or Bureau of Land Management (BLM).

3.5 Prioritizing Within and Between Land Use Classes

The CPUC stated in Decision 06-01-042, "[a]lthough equal mitigation for an entire class is a desirable goal, we will not limit the spending of EMF mitigation to zero on the basis that not all class members can benefit."[23]

While Decision 06-01-042 directs the utilities to favor schools, day-care facilities and hospitals over residential areas when applying low-cost magnetic field reduction measures, prioritization within a class can be difficult on a project case-by-case basis because schools, day-care facilities, and hospitals are often integrated into residential areas, and many licensed day-care facilities are housed in private homes that can be easily moved from one location to another. Therefore, utilities may group public schools, licensed day-care centers, hospitals, and residential together to receive highest prioritization for low-cost magnetic field reduction measures. Commercial and industrial areas may be grouped as a second priority group, followed by recreational and agricultural areas as the third group. Low-cost magnetic field reduction measures will not be considered for undeveloped land such as open space, state and national parks, Bureau of Land Management and National Forest Service Land.

When spending for low-cost measures would otherwise disallow equitable magnetic field reduction for all areas within a single land-use class, prioritization can be achieved by considering location and/or density of permanently occupied structures on lands adjacent to the projects, as appropriate.

[23] Ibid., p. 10

4 Field Management Plans for Transmission Lines

Construction of a new transmission line or the major upgrade of an existing transmission line, if they require GO-131D permitting, or the relocation of 2000 feet or more of an existing transmission line will require the preparation of a FMP; refer to § 3.3 to determine if a Detailed FMP (or Basic FMP) is needed; refer to § 3.4 for exemption criteria.

Transmission FMPs should include the following sections:

- Project Description;
- Evaluation of No-Cost Magnetic Field Reduction Measures;
- Evaluation of Low-Cost Magnetic Field Reduction Measures; and
- Recommendations including a table showing magnetic field reduction measures.

In addition to these requirements, a two-dimensional (2D) magnetic field model is required for a Detailed FMP.

4.1 Project Description

The project description portion of the transmission line FMP will include the following:

- For a Detailed FMP, the proposed line route should be shown on an attached project map illustrating the transmission line route, alternative line route (if applicable), and major streets and highways. A Basic FMP should briefly describe the scope of work including the line route;
- Description of land use adjacent to the line route for both Basic and Detailed FMPs;
- Circuit name and rated voltage, and circuit phasing if more than one circuit is present in the same corridor for both Basic and Detailed FMPs (rated 50 kV and above);
- Description of proposed design. For a Detailed FMP, include circuit configuration, and minimum ground clearance for overhead design. For a Basic FMP, include circuit configuration. For underground facilities (for both Detailed FMP or Basic FMP), show the depth and configuration of duct bank;
- Include estimated total project costs for proposed design.(for a Detailed FMP).

4.2 Two-Dimensional Magnetic Field Modeling for Transmission Lines

The purpose of magnetic field modeling is to evaluate relative effectiveness of various magnetic field reduction measures, not to predict magnetic field levels, as the CPUC recognized in Decision 06-01-042:

> "Utility modeling methodology is intended to compare differences between alternative EMF mitigation measures and not determine actual EMF amounts."[24]

[24] Ibid., p. 20

> "… the modeling indicates relative differences in magnetic field reductions between different transmission line construction methods, but does not measure actual environmental magnetic fields. In the same way, these relative differences in mitigation measures will be evident regardless of whether a maximum peak or a projected peak is used for the comparisons… It is also true that post construction measurement of EMF in the field cannot indicate the effectiveness of mitigation measures used as it would be extremely difficult to eliminate all other EMF sources."[25]

Two-dimensional magnetic field software can be used to evaluate the magnetic field characteristics of the proposed construction and various magnetic field reduction alternatives. Estimates of magnetic field levels are calculated based on a specific set of conditions. Therefore, it is important to make logical assumptions as to what these conditions will be and to keep these calculation conditions consistent when comparing two or more different cases.

Typical two-dimensional magnetic field modeling assumptions include:

- The line will be considered operating at forecasted design load;
- Magnetic field strength is calculated at a height of three feet above ground (assuming flat terrain);
- Resultant magnetic fields are being used;
- All line loadings are considered as balanced (i.e. neutral or ground currents are not considered);
- The line is considered working under normal operating conditions (emergency conditions are not modeled);
- Terrain is flat;
- Dominant power flow directions are being used; and
- Contribution of shield wire currents is not included.

[25] Ibid., p. 11

5 Field Management Plans for Substations

Construction of a new substation rated 50 kV and above or the major upgrade of an existing substation rated 50 kV and above will require the preparation of a substation FMP in a form of a check list (see example in Table 5-1). Magnetic field modeling for the substation project is not required.

A major upgrade for purposes of these Guidelines means the expansion of an existing substation through the addition of transformer bank(s) or new transmission line(s). "One-for-one" replacement of substation transformers, circuit breakers, or other apparatus does not constitute an major upgrade for purposes of these Guidelines, even if that replacement results in an increase in rated capacity. The addition of instrumentation, control, or protection equipment does not constitute a major upgrade. Refer to § 3.3 to determine if a substation FMP is needed, and to § 3.4 for exemption criteria.

Generally, magnetic field values along the substation perimeter are low compared to the substation interior because of the distance to the energized equipment. Normally, the highest values of magnetic fields around the perimeter of a substation are caused by overhead power lines and underground duct banks entering and leaving the substation, and not by substation equipment. Therefore, the magnetic field reduction measures generally applicable to a substation project are as follows:

- Site selection for a new substation;
- Setback of substation structures and major substation equipment (such as bus, transformers, and underground cable duct banks, etc.) from perimeter;
- Lines entering and exiting the substation (this will be a part of a transmission line FMP).

The Substation Checklist FMP evaluates the no-cost and low-cost measures considered for the substation project, the measures adopted, and reasons that certain measures were not adopted. An example Substation check list is shown below:

Table 5-1 Example of Substation Checklist for a FMP

No.	No-Cost and Low-Cost Magnetic Field Reduction Measures Evaluated for a Substation Project	Measures Adopted? (Yes/No)	Reason(s) if not Adopted
1	Keep high-current devices, transformers, capacitors, and reactors away from the substation property lines.	☐	
2	For underground duct banks, the minimum distance should be 12 feet from the adjacent property lines or as close to 12 feet as practical.	☐	
3	Locate new substations close to existing power lines to the extent practical.	☐	
4	Increase the substation property boundary to the extent practical.	☐	
5	Other:	☐	

6 California Department of Education's (CDE) Criteria for Siting New Schools Adjacent to Electric Power Lines Rated 50 kV and Above

The California Department of Education evaluates potential school sites under a range of criteria, including environmental and safety issues. Proximity to high-voltage power transmission lines[26] is one of the criteria. As the CPUC directed in Decision 06-01-042, the California investor-owned utilities worked with the CDE to align EMF Design Guidelines with the CDE's policies to the extent those policies were consistent with the CPUC's EMF Policy as stated in its Decision 06-01-042. As a result, the updated power line setback exemption guidelines were issued in May 2006. In revising its precautionary EMF approach, the CDE stated:

> "The proposed guidance acknowledges the scientific uncertainty of the health effects of EMFs, the lack of any state or nationally established standard for EMF exposure, and the PUC's recently reconfirmed reliance upon no/low-cost measures targeted to only reduce fields from new power transmission lines." [27]

CDE has established the following "setback[27]" limits for locating any part of a school site property line near the edge of easements for any overhead power lines rated 50 kV and above:

- 100 Feet for 50 – 133 kV Power Lines (interpreted by CDE up to 200 kV)
- 150 Feet for 220 – 230 kV Power Lines
- 350 Feet for 500 – 550 kV Power Lines

For underground power lines rated 50 kV and above, the CDE's setback distances are as follows:

- 25 feet for 50-133 kV line (interpreted by CDE up to 200 kV)
- 37.5 feet for 220-230 kV line
- 87.5 feet for 500-550 kV line

School districts that have sites which do not meet the CDE's setbacks may still obtain construction approval from the state by submitting an exemption application. Generally, school districts hire independent consultants who are familiar with the process to complete CDE's application requirements.

[26] *School Site Selection and Approval Guide*, California Department of Education
[27] "Power Line Setback Exemption Guidance - May 2006" by the California Department of Education