Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memos and Rulings on the Tehachapi Renewable Transmission Project (TRTP)

Before the

Public Utilities Commission of the State of California

Rosemead, California

December 3, 2012
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<td>ACR Response</td>
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<td>AEIC</td>
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<td>A&amp;G</td>
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I. OVERVIEW [C. Adamson]

Pursuant to the Scoping Memo and Ruling of Assigned Commissioner issued on July 2, 2012 (July 2012 ACR), as amended in the Amended Scoping Memo and Ruling of Assigned Commissioner dated November 15, 2012 (November 2012 ACR), Southern California Edison Company (SCE) developed a scalable full configuration to underground a 500 kilovolt (kV) transmission line in the existing right-of-way (ROW) through the City of Chino Hills (Chino Hills), should the California Public Utilities Commission (Commission) order SCE to modify the partially constructed overhead section of Segment 8A that was approved in the Certificate of Public Convenience and Necessity (CPCN) issued on December 17, 2009 (the Approved Route).\(^1\) SCE’s scalable full configuration accommodates both single- and double-circuit underground facilities with two or three cables per phase (collectively, the underground configurations), and provides the Commission with the ability to ensure that the existing ROW may be fully utilized.

To help focus the evaluation of whether underground construction should be undertaken, SCE in this testimony focuses on five specific underground configurations. Three of the five configurations have been previously identified in SCE’s Testimony in Response to the Assigned Commissioner’s Ruling on the Tehachapi Renewable Transmission Project (TRTP or the Project), dated January 10, 2012 (ACR Response) and Supplemental Testimony dated February 1, 2012 (Supplemental ACR Response). Rather than have continued cross-references to earlier testimony, SCE is presenting here the relevant information related to these five underground configurations, labeled UG1 through UG5. The configurations identified as UG1, UG4, and UG5 were identified in either the ACR Response or the Supplemental ACR Response.\(^2\) UG2 and UG3 are new underground configurations, but are logical combinations of components that are common to the full underground configuration.\(^3\)

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\(^1\) D.09-12-044 (Dec. 17, 2009).

\(^2\) UG1 is functionally equivalent to Option 6 described in the ACR Response. UG4 is functionally equivalent to Option 10 and UG5 is functionally equivalent to Option 11 described in the Supplemental ACR Response.

\(^3\) UG2 is an initial single-circuit configuration and UG3 is an initial single-circuit, two cables per phase implementation of Option 6 described in the ACR Response.
SCE refers to this testimony as the Preliminary Underground Testimony. Consistent with the November 2012 ACR, SCE will provide additional updated cost and schedule information in the amended testimony to be filed on February 28, 2012. In this Preliminary Underground Testimony, SCE has identified all the currently known issues and considerations, and has incorporated additional engineering and cost assessment work performed since the submission of the Supplemental ACR Response.

This Preliminary Underground Testimony also includes a preliminary schedule estimate based on a number of optimistic assumptions, including but not limited to: (1) the Commission would issue an interim order finding that SCE’s expenditure of costs related to advanced engineering and procurement efforts are prudent and in the ratepayers’ interest that allows SCE to undertake these efforts to manage the risk of delay; (2) there would be no delay resulting from supplemental environmental review by federal and state agencies; and (3) SCE could timely obtain any additional property rights from Chino Hills and private landowners that may be needed to place the transmission line underground. In other words, SCE’s time estimates contained in this testimony are based on heroic efforts and optimistic assumptions, providing a best case scenario aimed only to help the parties understand what a schedule may look like for these underground configurations.

These estimates do not account for the substantial risk of unexpected delays during the construction of an underground configuration, should the Commission adopt an underground design. There is no experience with 500 kV underground cable installation and operation in North America, and therefore no realistic predictors of the time it will take to successfully design, procure, manufacture, deliver, install, and test the 500 kV infrastructure. SCE has offered preliminary schedule estimates in this testimony, and SCE will continue work with Black and Veatch (B&V) and Power Delivery Consultants (PDC), and incorporate information from bidders, to develop more realistic time estimates in the testimony submitted on February 28, 2013.

This Preliminary Underground Testimony also describes the system needs and planning requirements impacting TRTP in general and Segment 8A in specific. Segment 8A of TRTP was
designed and approved as a double-circuit 500 kV transmission line, and this Preliminary
Underground Testimony reflects the need for infrastructure to eventually build out Segment 8A
to a double-circuit configuration, as approved in the California Independent System Operator
(CAISO) South Regional Transmission Plan for 2006 (CSRTP-2006).\(^4\) The double-circuit
design, whether overhead or underground, will be needed to support additional generation north
and east of Vincent and Lugo Substations and to address Los Angeles in-basin reliability
concerns.

To accommodate the full capability of TRTP, SCE’s scalable full configuration can be
implemented in either two or three cables per phase in a single- or double-circuit configuration,
resulting in five distinct underground configurations based on an ultimate double-circuit, three
cables per phase design (the Full Configuration). The two figures below show the orientation of
the typical duct banks and vaults in the existing ROW for the Full Configuration.

\(^{4}\) CAISO, \textit{South Regional Transmission Plan for 2006, Part II: Findings and Recommendation
on the Tehachapi Renewable Transmission Project} (Dec. 29, 2006), \textit{available at http://www.caiso.com/18db/18dbaedf2cca0.pdf}. CAISO approved TRTP in its current
design at its Board of Governors meeting on January 24, 2007. CAISO, \textit{General Session
Minutes, Board of Governor’s Meeting} (Jan. 24, 2007), \textit{available at http://www.caiso.com/Documents/Board-GovernorsMeetingMinutes
24-25Jan2007.pdf}. 
Figure 1a
Typical ROW with Duct Banks Cross-Section (Full Configuration)

Figure 1b
Typical ROW with Side-By-Side Vaults Cross-Section (Full Configuration)
Designing options for Segment 8A around the Full Configuration would allow the Commission to eventually accommodate the full build-out as approved by CAISO, should the Commission amend the CPCN to adopt Chino Hills’ request for underground construction in the Chino Hills area. This Preliminary Underground Testimony will also allow parties to compare the cost of the potential underground infrastructure needed to meet the full double-circuit capacity of the overhead design that was approved by the Commission in the CPCN.  

Brief descriptions of the underground configurations are as follows:

- **UG1 (also referred to as the Full Configuration):** A double-circuit cross-linked polyethylene (XLPE) transmission line using three cables per phase in conduit placed underground in SCE’s ROW in Chino Hills. UG1 is functionally equivalent to Option 6 described in the ACR Response.

- **UG2:** A single-circuit XLPE transmission line using three cables per phase, with ducts and structures installed for the second circuit, in conduit placed underground in SCE’s ROW in Chino Hills.

- **UG3:** A single-circuit XLPE transmission line using two cables per phase, with ducts and structures installed for a third cable and with ducts and structures installed for the second circuit, in conduit placed underground in SCE’s ROW in Chino Hills.

- **UG4:** A single-circuit XLPE transmission line using three cables per phase in conduit placed underground in SCE’s ROW in Chino Hills. UG4 is functionally equivalent to Option 10 described in the Supplemental ACR Response.

- **UG5:** A single-circuit XLPE transmission line using two cables per phase, with ducts and structures installed for a third cable, in conduit placed underground in SCE’s ROW in Chino Hills. UG5 is functionally equivalent to Option 11 described in the Supplemental ACR Response.

The five configurations identified in this Preliminary Underground Testimony addresses a full and reasonable range of configurations that preserve full use of the ROW, and also

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5 See D.09-12-044 at 28 (describing components of Segment 8A); id. at 51 (approving TRTP).
complies with the direction in the July 2012 ACR. UG1 identifies for the Commission and the
parties the full cost of undergrounding with the second circuit installed in a manner functionally
equivalent to the Approved Route’s overhead design, should the Commission decide to modify
the CPCN. This is necessary to make a fair comparison of the total cost of undergrounding with
the cost of the Approved Route. Although UG1 is a double-circuit configuration, the cable for
the second circuit need not be installed until the second circuit is needed to meet system
requirements.

SCE does not support undergrounding the transmission line in Chino Hills. If the
Commission were to order undergrounding, SCE’s preferred configuration initially is UG2,
which will allow the ducts and structures for both of the circuits to be installed in one
construction cycle and will also allow the ground surface to be graded and landscaped above the
ducts and structures. This allows flexibility as to the precise timing of installation of the second
circuit, and SCE would install the cable for the second circuit in the existing ducts and structures
with minimum construction disturbance to the community and minimal delay.

SCE is providing UG3, UG4, and UG5 to identify lower-cost initial configurations,
should the Commission desire to limit the near-term cost and defer the costs and impacts of the
full capacity configuration to a later date. SCE does not endorse any of these configurations, and
has significant concerns about the realistic ability to install the infrastructure for the second
circuit after the first circuit is operational. If the Commission were to select one of these
configurations, the Commission must accept that it could be dictating that the full capability of
the ROW may be lost.

In developing this Preliminary Underground Testimony, SCE worked with B&V and its
Project Manager, John Rector, and Engineering Manager, Forest Rong, to provide engineering
and cost assessment options. Founded in 1915, B&V is a leading global engineering consulting
and construction company specialized in the Energy, Water, Telecommunications, Federal, and
Management Consulting markets. B&V has been ranked by Engineering News-Record as the
industry’s number one design firm in Power and Telecommunications. B&V has been a key
contributor in the completion of hundreds of transmission and substation projects across the
United States.

B&V has extensive experience in all aspects of large underground transmission projects,
from study and engineering services to full Engineering, Procurement, and Construction (EPC).
B&V’s underground experience includes extruded dielectric cables (including XLPE), low
pressure self-contained fluid-filled cables, and high-pressure fluid/gas-filled pipe-type cables
projects. This experience allows B&V to provide the refined cost estimates for the underground
configurations requested by the Commission, as B&V understands and appreciates the
procurement and construction aspects of underground construction.

This Preliminary Underground Testimony describes the following: (1) transmission
planning considerations indicating a need for the second circuit approved by CAISO in its review
of TRTP; (2) system planning requirements for determining the size and number of cables per
phase; (3) electrical current carrying capacity of commercially available undergrounding cables
as installed in this design; and (4) engineering attributes for 500 kV underground installations.
This Preliminary Underground Testimony also provides a summary of estimated costs for, and
an overview of each, potential underground configuration in Chino Hills.

II. REGIONAL LONG-TERM TRANSMISSION PLANNING REQUIREMENTS

This section discusses the prudent transmission planning principles that warrant a
configuration of any underground construction in Chino Hills to be capable of expansion to a
double-circuit design.

A. Existing Transmission Capacity Is Not Expected to Be Sufficient for
   Future Needs [J. Chacon]

The current transmission capacity in SCE’s transmission system is constrained, and
several factors are expected to drive further growth requiring additional transmission capability.
These factors include new generation resources in the portion of SCE’s transmission system
referred to as the Northern Hemisphere (which includes the Northern and Lugo Areas of SCE’s
system), the interaction of new generation resources between the Northern and Lugo Areas of
SCE’s transmission system, potential future increases to Renewables Portfolio Standard (RPS)
targets, in-basin generation retirements, and/or system load growth. Each of these potential factors warranting a double-circuit-capable configuration is discussed in greater detail below.

1. New Generation Resources

   a. Location of New Resources

Designing Segment 8A as a double-circuit transmission line will accommodate new generation resources located in SCE’s Northern Area and Lugo Area. These two areas are collectively referred to as SCE’s Northern Hemisphere and are connected together via two existing 500 kV transmission lines between SCE’s Lugo Substation and SCE’s Vincent Substation. Upon TRTP’s completion, the Northern Hemisphere will be connected to SCE’s load center in the Los Angeles Load Basin via the following ten transmission lines:

- Three existing 500 kV transmission lines between the Lugo Substation and the Rancho Vista and Mira Loma Substations.
- Two existing 220 kV transmission lines between the Pardee Substation and the Sylmar Substation.
- Two existing 220 kV transmission lines between the Vincent Substation and the Rio Hondo Substation. One of these lines was previously partially constructed with 500 kV design standards. As part of TRTP, the line will be fully constructed to 500 kV design standards but operated at 220 kV.
- One existing 220 kV transmission line between the Vincent Substation and the Mesa Substation.
- The existing Eagle Rock-Pardee 220 kV transmission lines, which will be modified as part of TRTP to form Segment 11.
- A new 500 kV transmission line between the Vincent Substation and the Mira Loma Substation formed as part of TRTP Segments 6, 7, and 8. The portion of line between the City of Duarte and the Mira Loma Substation (Segments 7 and 8) will be constructed as a double-circuit, but operated as a single circuit.

Figure 2a, below, depicts a geographical representation of SCE’s Northern Hemisphere with connections to the load centers provided by the existing transmission infrastructure and new
transmission under construction as part of TRTP. Figure 2b, below, provides the one-line representation of these connections and illustrates upgrades implemented as part of TRTP.

Figure 2a
Geographic Representation of SCE’s Northern Hemisphere with TRTP
One Line Diagram of SCE’s Transmission Connection to Northern Hemisphere

Legend
- 220 kV (Existing)
- 220 kV (TRTP)
- 500 kV (Existing)
- 500 kV (TRTP)

Existing and new generation resources are and will be competing for available transmission south from SCE’s Northern Hemisphere to SCE’s load center. This includes resources from the following areas:

- **Northern Area**: Consisting primarily of generation resources in the Antelope Valley, Big Creek Corridor, Santa Clarita, the Tehachapi region, and Ventura County;
- **Lugo Area**: Consisting primarily of generation resources in the Eldorado-Ivanpah area, Mohave area, Pisgah area, North of Kramer region, and the Victorville/Hesperia/Apple Valley region; and
- **Additional Imports**: Imports from Northern California and the Pacific Northwest on Path 26 into Vincent Substation, and imports from Southern Nevada on the Eldorado-Lugo and Lugo-Mohave 500 kV transmission lines into the Lugo Substation.
b. Studies Determining Need for Transmission Upgrades

Do Not Account for All New Generation

SCE identifies the need for additional system upgrades through specific generation interconnection studies performed as part of the generation interconnection process. These specific studies evaluate whether the electric system can support the interconnection of additional generation resources, the majority of which in the Northern Hemisphere are renewable. SCE’s generation interconnection studies include power flow, voltage stability, transient stability, and short-circuit duty. Except for short-circuit duty studies, these generation interconnection studies are typically performed for generation resources in the Northern Area and Lugo Area independently from each other and from other areas.

The generation interconnection studies are used to define the Reliability Network Upgrades (RNU) and Delivery Network Upgrades (DNU). RNU are necessary to interconnect the generation resource under Energy Only deliverability status. DNU are identified by CAISO as the upgrades needed to provide Resource Adequacy (RA) to the generators seeking Full Capacity deliverability status.

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6 Short-circuit duty is the current provided by all generators connected to the electric system that interrupting devices such as circuit breakers need to withstand to safely and properly disconnect faulted or failed components of the electric system. The amount of short circuit duty contribution of each generation resource to a specific fault depends on the electrical impedance between the generation resource and the location of the system fault. Short-circuit duty studies are the assessments performed that identify these short-circuit duties and determines if the interrupting devices are adequate to safely disconnect faulted or failed components of the electric grid.

7 As part of the generation interconnection study process, CAISO performs Deliverability Assessments in addition to SCE’s studies.

8 Energy Only deliverability status is defined in the CAISO Tariff within Appendix A (Master Definitions Supplement) as a condition elected by an Interconnection Customer for a Large Generating Facility interconnected with the CAISO Controlled Grid, so that the Interconnection Customer is responsible only for the costs of RNU and is not responsible for the costs of DNU. CAISO Fifth Replacement Tariff at Appendix A (Nov. 5, 2012), available at [http://www.caiso.com/Documents/TariffAppendixA_Nov5_2012.pdf](http://www.caiso.com/Documents/TariffAppendixA_Nov5_2012.pdf). The Large Generating Facility, however, will be deemed to have a Net Qualifying Capacity of zero and, therefore, cannot be considered to be a Resource Adequacy Resource. In other words, these are the subset of upgrades needed to interconnect but not necessarily allow a project to generate power.

9 Resource Adequacy is a Commission program that has the following two goals: (1) provide sufficient resources to the CAISO-controlled grid to ensure the safe and reliable operation of the grid in real-time; and (2) provide incentives for siting and constructing new resources.
CAISO’s Generator Deliverability Assessment (Deliverability Assessment) analyzes whether each electrical area can accommodate the full output of all of its capacity resources and export, at a minimum, whatever power is not consumed by local loads during periods of peak system load. In the Deliverability Assessment, CAISO makes several assumptions that artificially lower generation dispatch assumptions for all queued generation projects in the studies performed from what would actually occur if these resources ultimately develop. The reduction in dispatch is attributed to the Deliverability Assessment’s focus, which is solely to define DNUs needed for those resources seeking Full Capacity deliverability status in order to be eligible for RA. As a result, all Federal Energy Regulatory Commission (FERC) jurisdictional resources that are not seeking Full Capacity deliverability status and all Commission jurisdictional Rule 21 and Net Energy Metering (NEM) Projects are referred to as Energy Only resources. Accordingly, CAISO’s Deliverability Assessment does not include or represent Energy Only resources or identify the need for RNUs. That is, the output from Energy Only resources is assumed to be zero in the CAISO’s Deliverability Assessment, which is not reflective of what would actually occur if the queued Energy Only resources ultimately develop.

Another limiting factor in the Deliverability Assessment is that resources requesting Full needed for reliability in the future. See Cal. Pub. Util. Code § 380 (codifying the resource adequacy policy framework).

Full Capacity deliverability status is defined in the CAISO Tariff within Appendix A (Master Definitions Supplement) as a condition whereby a Large Generating Facility interconnected with the CAISO Controlled Grid, under coincident CAISO Balancing Authority Area peak demand and a variety of severely stressed system conditions, can deliver the Large Generating Facility’s full output to the aggregate of Load on the CAISO-controlled grid, consistent with CAISO’s Reliability Criteria and procedures and the CAISO On-Peak Deliverability Assessment. ISO Fifth Replacement Tariff at Appendix A (Nov. 5, 2012), available at http://www.caiso.com/Documents/TariffAppendixA_Nov5_2012.pdf.


Electric Rule 21 is a tariff that describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility’s distribution system, over which the Commission has jurisdiction. SCE, Rule 21: Generating Facility Interconnections (Sept. 20, 2012), available at http://www.sce.com/NR/sc3/tm2/pdf/Rule21_1.pdf.

Customers who install small solar, wind, biogas, and fuel cell generation facilities (1 MW or less) to serve all or a portion of onsite electricity needs are eligible for the state’s NEM program. NEM allows a customer-generator to receive a financial credit for power generated by their onsite system and fed back to the utility. The credit is used to offset the customer’s electricity bill. See Cal. Pub. Util. Code § 2827 (establishing NEM program).
Capacity deliverability status are dispatched to 80% of their Net Qualifying Capacity (NQC) where NQC is based on technology type.\textsuperscript{14}

CAISO’s Deliverability Assessment dispatch assumptions do not reflect the actual amount of generation potentially available because they inherently assume a significant amount of curtailment in place before the Deliverability Assessment is even performed. Any upgrades identified by the Deliverability Assessment will therefore accommodate the output of only a portion of the total number of generation projects seeking interconnection. Consequently, the collection of RNUs and DNUs prescribed by CAISO generation interconnection studies will not provide sufficient transmission capability to avoid potentially significant curtailments of both resources seeking Full Capacity deliverability status and resources seeking Energy-Only deliverability status when the total installed capacity of new resources exceeds the incremental 4,500 megawatts (MW) of transmission capability that would be provided by TRTP. Generation in excess of the capacity provided by the transmission upgrades would have to be curtailed.

c. New Generation May Exceed Capacity, Resulting in Curtailment

CAISO’s Deliverability Assessment dispatch assumptions identified a limited amount of transmission necessary to provide generators with the Full Capacity deliverability status. The need for curtailment, however, would arise in real-time when actual generation exceeds the CAISO’s dispatch assumptions and the transmission capability is insufficient to deliver power from these generating resources to the load centers. These curtailments could adversely impact California’s progress towards RPS goals, because the RPS goals are based on meter-spin, and curtailments inhibit the meter from spinning.\textsuperscript{15}

\textsuperscript{14} NQC is the concept used to describe the capacity from each resource that can utilized by a Load Serving Entity, such as SCE, to satisfy its overall Resource Adequacy obligation. CAISO, \textit{On-Peak Deliverability Assessment Methodology (for Resource Adequacy Purposes)} at 5 (Apr. 10, 2009), available at \url{http://www.caiso.com/23d7/23d7e41c14580.pdf}.

\textsuperscript{15} See California Senate Bill (SB) X1-2 (2011) (codifying 33% by 2020 RPS); see also SB 1078 (2002) (establishing RPS program). The percent RPS attained is derived by dividing the total Renewable Energy Procurement by the total Retail Sales. Both the Renewable Energy Procurement and Retail Sales are in terms of megawatt-hours, which is energy measured by the meter “spinning.” Consequently, curtailment of generation resources in renewables-rich areas with large number of executed Power Purchase Agreements, such as
The amount of generation curtailed will be a function of real-time load, generation bids for dispatch, actual generation output from intermittent generation resources that differs from cleared bids for generation dispatch, and the amount of transmission capacity available. Both SCE’s Northern Area and Lugo Area contain more queued generation resources than there is local load demand and thus will be exporting generation to major load centers through transmission common to both areas. As more generation resources are added to SCE’s Northern Hemisphere without additional transmission upgrades beyond those approved as part of TRTP, the amount of latent or unused transmission capacity to transmit these resources will diminish. While TRTP provides significant incremental transmission capability and will therefore be essential to ensuring curtailment is limited to the extent possible, TRTP will not by itself support all of the anticipated generation from the Northern Hemisphere.

As of November 1, 2012, there were 11 active projects in the Lugo Area through Queue Cluster 4 with executed Generator Interconnection Agreements (GIAs) totaling 1,293 MW, and 26 active projects through Queue Cluster 4 with executed GIAs totaling 4,465 MW in the Northern Area. The projects through Queue Cluster 4 have proceeded through the Northern Area, due to inadequate transmission would reduce the total Renewable Energy Procurement megawatt-hours thereby lowering the attained percent of the RPS goals. See also Paul Douglas, Commission, California’s Renewables Portfolio Standard: Overview and Trends of the Growing Renewable Wholesale Market (Aug. 20, 2012), available at http://www.naruc.org/International/Documents/NARC_Mexico%20CRE_CA%20Mkt%20Overview_PPT1_Paul%20Douglas_eng.pdf.

Intermittent resources, such as wind generation, can participate in the CAISO Participating Intermittent Resource Program (PIRP) that allows such intermittent resources to schedule energy in the Forward Market (day-ahead and hour-ahead) without incurring real-time imbalance charges when the delivered energy differs from the scheduled amount. CAISO, Participating Intermittent Resource Program Initiative, available at http://www.caiso.com/docs/2003/08/15/2003081515132828593.pdf.

A queue cluster represents a group of generation projects seeking interconnection that submitted their interconnection requests within the timeframes open for that particular queue cluster. These queue clusters are sequential in nature; for example, Queue Cluster 4 follows Queue Cluster 3. As of November 1, 2011, a total of five queue cluster windows have been opened. Only the projects through Queue Cluster 4 have progressed along the interconnection study process to the point where interconnection agreements can be executed. However, Queue Cluster 5 contains additional resources requesting to interconnect to SCE’s Northern Hemisphere, and, if successful, those resources would further stress the TRTP system.

GIAs include Small Generator Interconnection Agreements, Large Generator Interconnection Agreements, and GIAs under the new cluster interconnection process.
interconnection process to a point where they have either executed or are in a position to negotiate and execute a GIA because they have completed their interconnection study process. These projects are summarized in Table 1.

Table 1
Active Generation Projects through Queue Cluster 4 with Executed GIAs

<table>
<thead>
<tr>
<th>Area</th>
<th>Location</th>
<th>Number of Interconnection Requests</th>
<th>Resource Type</th>
<th>MW</th>
<th>Total MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lugo Areas</td>
<td>Ivanpah</td>
<td>3</td>
<td>Solar</td>
<td>392</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Victor Subtransmission</td>
<td>3</td>
<td>PV</td>
<td>550</td>
<td>1,293</td>
</tr>
<tr>
<td></td>
<td>Jasper</td>
<td>1</td>
<td>Wind</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>North of Kramer</td>
<td>1</td>
<td>Solar</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Northern Area</td>
<td>Antelope Subtransmission</td>
<td>6</td>
<td>PV</td>
<td>183</td>
<td></td>
</tr>
<tr>
<td></td>
<td>North of Magunden</td>
<td>1</td>
<td>PV</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>North of Magunden</td>
<td>1</td>
<td>Gas</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Saugus</td>
<td>1</td>
<td>Biomass</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ventura</td>
<td>1</td>
<td>Gas</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vincent</td>
<td>1</td>
<td>Wind</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whirlwind</td>
<td>4</td>
<td>PV</td>
<td>1,050</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windhub/Highwind</td>
<td>8</td>
<td>Wind</td>
<td>2,469</td>
<td></td>
</tr>
</tbody>
</table>

In addition to the active generation projects with executed GIAs, there are 36 active projects totaling 4,251 MW in the Lugo Area, and 78 active projects totaling 5,051 MW in the Northern Area through Queue Cluster 4 that are in the interconnection queue, but do not yet have an executed GIA or that have an agreement in place but the project is currently suspended. These projects are summarized in Table 2.

19 PV refers to photovoltaic solar generation resources.
Table 2
Active Generation Projects without Executed GIAs

<table>
<thead>
<tr>
<th>Area</th>
<th>Location</th>
<th>Number of Interconnection Requests</th>
<th>Resource Type</th>
<th>MW</th>
<th>Total MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lugo Areas</td>
<td>Eldorado/Mohave</td>
<td>5</td>
<td>PV</td>
<td>1,215</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pisgah</td>
<td>3</td>
<td>Solar</td>
<td>1,650</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VEA System</td>
<td>2</td>
<td>Solar</td>
<td>810</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Victor Subtransmission</td>
<td>20</td>
<td>PV</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jasper</td>
<td>1</td>
<td>PV</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Geo</td>
<td>141</td>
<td></td>
</tr>
<tr>
<td></td>
<td>North of Kramer</td>
<td>1</td>
<td>PV</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Wind</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Northern Area</td>
<td>Antelope</td>
<td>45</td>
<td>PV</td>
<td>1,158</td>
<td></td>
</tr>
<tr>
<td></td>
<td>North of Magunden</td>
<td>13</td>
<td>PV</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ventura</td>
<td>1</td>
<td>Gas</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>PV</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vincent</td>
<td>1</td>
<td>Gas</td>
<td>570</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Wind</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whirlwind</td>
<td>8</td>
<td>PV</td>
<td>1,249</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Wind</td>
<td>1,090</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Windhub/Highwind</td>
<td>3</td>
<td>PV</td>
<td>620</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>Wind</td>
<td>33</td>
<td></td>
</tr>
</tbody>
</table>

Adding both active generation projects with executed GIAs and projects that do not yet have an executed GIA or that have an agreement in place but are currently suspended results in a total of 5,544 MW in the Lugo Area and a total of 9,516 MW in the Northern Area.20

Recent information being compiled for the Desert Renewable Energy Conservation Plan (DRECP)21 identified several alternative generation MW values for different development focus areas. The West Mohave Emphasis Alternative resulted in a total Northern Area resource level of 9,497 MW22 and a total Lugo Area resource level of 8,886 MW.23 Whether viewing active

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20 These totals exclude the numerous Rule 21 and NEM Projects developing in the Northern Hemisphere.

21 The DRECP is a major component of California’s renewable energy planning efforts which will help provide effective protection and conservation of desert ecosystems while allowing for the appropriate development of energy projects. For additional information, see http://www.drecp.org/.

22 The following DRECP identified Development Focus Areas (DFAs) are within the Northern Area: Tehachapi, Antelope-Vincent, and Edwards. See SCE, DRECP TTG Meeting Presentation at 12 (Sept. 5, 2012) (describing the resources within each DFA), available at http://www.drecp.org/meetings/2012-09-05_ttg_meeting/2012-09-05_ttg_presentation.pdf.

23 The following DRECP identified DFAs are within the Lugo Area: Barstow, China Lake and Fort Irwin, Lugo-Victorville-Jasper, Owens Valley, and Ridgecress & Hwy 395. See SCE, DRECP TTG Meeting Presentation at 12 (Sept. 5, 2012) (describing the resources within
projects with GIAs, active projects without GIAs, or analyzing expected generation from other
energy study efforts, generation in the Northern Hemisphere is expected to exceed the
incremental 4,500 MW of capacity provided by TRTP.

2. Interaction Between Northern Area and Lugo Area

Generation Resources

The following discussion provides analysis of how TRTP is important not only for
generation projects in the Tehachapi area, but to SCE’s transmission system as a whole.

a. Using Nomograms to Assess Transmission System Capacity

Operational nomograms are sets of operating or scheduling rules used by transmission
planners and grid operators to ensure that simultaneous operating limits based on two or more
different variables are respected. In the case of transmission capacity from the Northern
Hemisphere, the two different variables involve the volume of generation imports into the Los
Angeles load basin from the Northern Area and from the Lugo Area. The interaction of the
generation imports affects the maximum amount of power that can be transmitted south of SCE’s
Vincent Substation (South of Vincent), which is represented by the “curves” on the nomogram
graphs below. Real-time transmission operators must ensure generation levels remain below the
curve to ensure overall system reliability is maintained. Operating above the nomogram curve
would subject the system to a violation of the North American Electric Reliability Corporation
(NERC), Western Electricity Coordinating Council (WECC), and CAISO Reliability
Standards.24

CAISO has identified various transmission constraints for importing Northern Area and
Lugo Area generation into the Los Angeles load basin, including the Vincent 500/220 kV
each DFA), available at http://www.drecp.org/meetings/2012-09-05_ttg_meeting/2012-09-
05_ttg_presentation.pdf.

See NERC, Reliability Standards for the Bulk Electric Systems of North America (updated
November 19, 2012), available at http://www.nerc.com/docs/standards/rs/Reliability_Standards_Complete_Set.pdf. See also
WECC, System Performance Criteria (adopted December 1, 2011), available at
http://www.wecc.biz/library/Documentation%20Categorization%20Files/Regional%20Criter
transformer bank thermal limits and the South of Lugo transmission capacity. TRTP was in part
designed to address the South of Lugo transmission constraints. More broadly, TRTP will
allow for greater transmission capacity South of Vincent to deliver power to the Los Angeles
load basin. Given the magnitude of new generation interconnection requests in SCE’s Northern
Hemisphere, the interaction between the Northern Area and Lugo Area will play a critical role in
defining the need for additional system expansion. Specifically, generation resources in the
Northern Area will impact South of Lugo and South of Vincent power flows while resources
located in the Lugo Area will impact the amount of Northern Area resources that can be
accommodated by TRTP. Nomograms are therefore useful to examine the projected system
conditions under various Northern Area and Lugo Area generation scenarios, where both Areas
are trying to transmit power South of Vincent to the Los Angeles load basin.

Computer simulations were performed for Queue Cluster 3 and 4 Phase II generation
interconnection studies using the forecast 2015 summer and spring load conditions as requested
by CAISO. Critical power flow cases were developed that maximized generation resources in
the Northern Area while limiting the Lugo Area resources to identify the maximum power flow
South of Vincent that could be accommodated under summer and spring load conditions while
maintaining overall system reliability. This was selected as the appropriate starting point

25 See D.09-12-044 at 25 (discussing TRTP’s objective to address South of Lugo transmission
constraints).

26 South of Lugo power flow is the sum of the flows on the three 500 kV transmission lines
from Lugo to Mira Loma and Rancho Vista Substations.

27 South of Vincent power flow is the sum of the flows on the following transmission lines:

- Two existing Lugo-Vincent 500 kV transmission lines;
- Two existing Rio Hondo-Vincent 220 kV transmission lines;
- Two existing Pardee-Sylmar 220 kV transmission lines;
- One existing Mesa-Vincent 220 kV transmission line;
- One existing Eagle Rock-Pardee 220 kV transmission line which will be replaced by a
  new Mesa-Vincent 220 kV transmission line as part of TRTP; and
- The new Mira Loma-Vincent 500 kV transmission line which will be provided with the
  completion of TRTP.

28 System reliability was determined under outage conditions as required by the NERC
Reliability Standards. See NERC, Reliability Standards for the Bulk Electric Systems of
North America (updated November 19, 2012), available at
because the maximum South of Vincent power flow has been well established through numerous studies performed as part of the CSRTP-2006 or as part of the numerous Northern Area generation interconnection studies.

The generation resources in the Northern and Lugo Areas were then systematically readjusted to reflect increasing generation dispatch totals from the Lugo Area. The increased generation dispatch in the Lugo Area affected the maximum amount of generation dispatch from the Northern Area, resulting in a decrease in the total South of Vincent power flow from the Northern Area. The increased Lugo Area dispatch is represented by the increases in total Lugo Import. These calculations resulted in a series of topologies representing South of Vincent power flow under various iterations of TRTP, which are discussed below.

b. System Capacity Before and After the Construction of TRTP

Based on the computer simulations, Figure 3 illustrates the resulting operational nomograms for the system topology with all of TRTP included, except the portions of Segment 8 and Segment 11 that are not yet in service. Critically, the topology does not include the Mira Loma-Vincent 500 kV transmission line because all of Segment 8, including Segment 8A, is required to energize this transmission line. The topology also does not include the second Mesa-Vincent 220 kV transmission line to be completed by Segment 11.


29 Lugo Import is the sum of the flows on the following transmission facilities:

- Two existing Lugo 500/220 kV transformer banks;
- Lugo-Mohave 500 kV transmission line; and
- Eldorado-Lugo 500 kV transmission line.
Figure 3
Northern Hemisphere Import Nomogram - Without Segments 8 & 11

The top curve represents the study results obtained under heavy summer load assumptions, while the bottom curve represents the study results under lighter spring load assumptions. These two nomogram curves provide the high end and low end of an actual operating nomogram under the system topology that includes all of TRTP (except the new Mira Loma-Vincent 500 kV and new Mesa-Vincent No. 2 220 kV transmission lines, as described above). During real-time operations, the actual nomogram, or capacity limitation, will be somewhere in the middle of the two curves.

As demonstrated in Figure 3, the maximum South of Vincent flow (best case scenario) that the system topology without Segments 8 and 11 can accommodate is approximately 5,300 MW. A conservative maximum level (worst case scenario) is approximately 4,800 MW. As shown by the curve, maximum levels will degrade once Lugo Area imports are increased by
dispatching Lugo Area resources. The reduction in system capability is attributed to many
system limitations, including South of Lugo transmission constraints that TRTP is designed to
mitigate.30

Computer simulations were again performed by including the new Mesa-Vincent 220 kV
transmission line that would be energized with the completion of Segment 11. Based on the
computer simulations, Segment 11 without the completion of Segment 8 will not meaningfully
increase system capability. Any increase would be only marginal due to capacity limitations on
the Vincent 500/220 kV transformer banks31 and due to transmission constraints South of Lugo.

As demonstrated in Figure 4, the maximum South of Vincent flow (best case scenario)
that the system topology without the new Mira Loma-Vincent 500 kV transmission line can
accommodate is approximately 5,400 MW. A conservative maximum level (worst case
scenario) is approximately 5,200 MW.

30 The resulting nomogram without the new Mira Loma-Vincent 500 kV and new Mesa-
Vincent No. 2 220 kV transmission lines will be further reduced during construction of
Segment 11 if the new Mira Loma-Vincent 500 kV transmission line is not placed into
service before taking the outage on the existing Pardee-Eagle Rock 220 kV transmission line
(which outage is required to construct the portion of Segment 11 between the Gould and
Vincent substations). Consequently, any delay in Segment 8 will negatively impact the
amount of available transmission capacity while Segment 11 is being constructed.

31 System capacity is limited by the amount of flow that can be supported on the Vincent
500/220 kV transformer banks following loss of both Lugo-Vincent 500 kV transmission
lines. The two Lugo-Vincent 500 kV transmission lines are adjacent circuits on separate
towers for the entire distance, which must be evaluated as a common mode failure consistent
with NERC/WECC Standards. See NERC, Reliability Standards for the Bulk Electric
Systems of North America (updated November 19, 2012), available at
http://www.nerc.com/docs/standards/rs/Reliability_Standards_Complete_Set.pdf. See also
WECC, System Performance Criteria (adopted December 1, 2011), available at
http://www.wecc.biz/library/Documentation\00C2\0080Categorization\20Files/Regional\%20Criter-
ia\\%00E2\\%80%9C\0020-\%20Effective\00A0April\%00E2\\%80%9C%00202012.pdf.
To increase system capacity in a meaningful way, the Vincent 500/220 kV transformer bank limitations and transmission constraints South of Lugo must be addressed. Segment 8 is critical to addressing both system limitations. First, Segment 8 will enable completion of a new 500 kV line directly to Mira Loma, bypassing the the Vincent transformer banks and attendant limitations. Second, Segment 8 will include a new Mira Loma-Vincent 500 kV transmission line parallel to the three existing South of Lugo 500 kV transmission lines, thereby providing an alternative electrical path South of Lugo. This additional 500 kV path will enable additional loading on the three existing South of Lugo 500 kV transmission lines because the incremental flow under loss of two of the three 500 kV transmission lines, which limit the total capability, will be supported by the new Mira Loma-Vincent 500 kV line.
The operational nomogram for the system with all of TRTP in place, including Segments 8 and 11, is illustrated below in Figure 5. The maximum South of Vincent flow (best case scenario) that this system topology can accommodate is approximately 8,600 MW. A conservative maximum level (worst case scenario) is approximately 6,600 MW.

**Figure 5**
Northern Hemisphere Import Nomogram - Complete TRTP

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### c. Operating Performance and Curtailment Scenarios With and Without TRTP

Using nomograms during system operation would demonstrate potential reliability concerns attributed to inadequate transmission capacity by allowing the system operators to readily identify potentially unsafe operating conditions. Under such unsafe conditions, the system operator would implement curtailment of generation resources to ensure real-time
operating conditions are brought back to within a safe operating area (i.e., under the nomogram curve).32

The current curtailment mechanisms involve established market dispatch protocols referred to as Congestion Management, which were implemented after CAISO’s Market Redesign Technology Upgrade (MRTU) Project.33 In general, the curtailment is implemented in the day-ahead market based on the amounts of generation bid, corresponding market bid prices and schedule load, with adjustments made in the hour-ahead and real-time markets.

CAISO’s curtailment management protocols may not be effective in real-time operations, however, due to the magnitude and intermittent nature of the renewable generation resources seeking interconnection in SCE’s Northern Hemisphere. As discussed above, the PIRP enables wind and solar generators to bid or schedule resources in the day-ahead and hour-ahead markets, but accepts real-time production that will differ from what was scheduled. Such real-time production difference may not allow for the effective use of congestion management protocols to effectively and properly curtail generation resources based on bid price. As such, operators may need to examine the effectiveness of the day-ahead and hour-ahead markets and develop additional curtailment processes to address real-time operations.

SCE evaluated year 2011 historical data to identify historical operating performance within the South of Vincent / Lugo Import nomogram identified in Figure 3 (current capacity without TRTP Segments 8 and 11). Operation before including any new generation resources is within the overall existing system capability, represented by the scatter plot below in Figure 6. Each scatter point represents the values obtained for each hour in 2011.34

32 The exact nature of the curtailment procedures will need to be developed and approved by CAISO and SCE System Operators.
34 Year 2011 flows corresponding to all new generation resources interconnected at Windhub was removed from the 2011 South of Vincent flow totals because significant generation curtailment of these resources was implemented throughout year 2011 and because the exact amount of new generation installed throughout 2011 varied as individual wind generation units were in-serviced and brought on-line.
As demonstrated in Figure 7 below, as generation resources are added to the Northern Hemisphere, generation output may exceed current transmission capacity, depending on the volume and location of the new resources. To estimate the near-term operating performance associated with interconnecting all new generation resources anticipated in the Northern Hemisphere, SCE analyzed projects with executed, active GIAs. These are the projects summarized above in Table 1. Year 2011 production profiles for photovoltaic (PV) solar, non-PV solar, and wind generation resources were used as a proxy to represent expected performance for each new resource type. The production profiles PV profiles used were based on fixed-PV technology as there is currently insufficient data to adequately represent tracking-PV technology. It is important to note that tracking-PV technology profiles have a wider daily production resulting in higher production amounts for more periods of the day as compared to fixed-PV technology. Because most large-scale PV projects are utilizing tracking-PV technology, the PV profiles used in this analysis are conservative, meaning they potentially underestimate the amount of generation production and corresponding amount of potential congestion.
were added to the historical data to develop a new set of scatter points that would represent year 2011 performance that included the new generation resources. The resulting data, illustrated below in Figure 7, confirms that the transmission system will require generation curtailment until Segment 8 is completed and the Mira Loma-Vincent 500 kV transmission line becomes operational. The magnitude and amount of curtailment will grow as more generation resources execute GIAs and commence project development and operations.

Figure 7
Anticipated Operating Region Including New Generation With Executed GIAs

Based on analysis performed by SCE’s Generation Interconnection Planning group, while the expected performance for various technologies suggests potential congestion and curtailment exposure when overlaid on the nomogram, the realized amount of congestion and curtailment could be significantly larger. Factors that would drive greater congestion and curtailment include the level of safety margin desired by the system operators. Because the best case and
conservative case nomogram curves represent ideal system conditions with all facilities in-service, these curves could be further reduced or lowered to provide for such additional operational margin to ensure system reliability is maintained under all operating conditions.

Once Segment 8 is completed, bringing the Mira Loma-Vincent 500 kV transmission line into service, the need for generation curtailments will disappear until additional generation resources are developed. Completing Segment 8 allows the nomogram curves to be moved up, increasing the maximum South of Vincent flow from 5,300 MW to 8,600 MW (best case scenario) and increasing the conservative level from 4,800 MW to 6,500 MW. Compared to the system capability that currently exists, Segment 8 will allow the South of Vincent flow to increase 3,300 MW (or 1,700 MW under the conservative scenario).

While a fully completed TRTP will increase system capacity, this capacity will be limited to a total South of Vincent flow of approximately 8,600 MW under a maximum best case scenario. Consequently, the need for increased system capacity will arise over time as more generation resources are interconnected in SCE’s Northern Hemisphere. Anticipating future operating performance can be viewed by applying the same adjustment methodology discussed above and plotting the resulting scatter points on the nomogram derived following completion of TRTP. As Figure 8 illustrates, even after all TRTP Segments are complete, transmission capacity will be inadequate to support all generation projects through Queue Cluster 4 seeking interconnection. Although it is unlikely that all projects seeking interconnection through Queue Cluster 4 in the Northern Hemisphere will actually materialize, and the methodology implemented does not necessarily portray actual dispatch conditions that will occur, the fact remains that additional capacity will be required in the future as more resources interconnect in the Northern Hemisphere than can be supported by the transmission capacity provided by TRTP. Consequently, prudent TRTP design should facilitate the addition of incremental transmission capacity in the future should it become necessary to integrate more generation resources in SCE’s Northern Hemisphere.
Based on the amount of new generation located in the Northern Hemisphere, it is important that TRTP be built according to schedule and with the same double-circuit design considerations as the Approved Route to facilitate incremental transmission needed to support more generation resources.

3. Additional Transmission Planning Considerations Warranting Double-Circuit Design

Potential Additional Increases in RPS Goals. Load serving entities are required to meet a specific proportion of total energy sales through the purchase of renewable energy. Currently, the RPS goal is set at 33% of total energy sales.\(^{37}\) However, state policy may increase

\(^{37}\) See California Senate Bill (SB) X1-2 (2011) (codifying 33% by 2020 RPS); see also SB 1078 (2002) (establishing RPS program).
the RPS goal, which would encourage more renewable resource development in the Northern
Hemisphere’s renewables-rich areas. Any future increases to RPS goal could therefore drive the
need for additional transmission to deliver even more renewable resources to the load centers.
Any increase in the amount of new generation that ultimately develops in the Northern
Hemisphere to serve load demands in Southern California would only exacerbate the
transmission constraints identified above.

Retirement of In-Basin Generation. In-basin generation retirement, whether attributed
to the State Water Resources Control Board’s Once-Through Cooling policy or any other factor,
will require additional electricity generation to replace the output of any retired generation units.
The replacement energy can come from in-basin unit repowers, new in-basin generation, out-of-
basin generation imports or a combination of all three. As discussed above, TRTP’s
transmission capacity is limited. Depending on the pace of in-basin generation unit retirement,
replacement energy from SCE’s Northern Hemisphere will be limited to the capabilities provided
by TRTP, unless additional transmission is made available.

System Load Growth. An additional consideration is load growth, or the demand for
electricity that SCE’s transmission must adequately be able to support. In the short-term, the
amount of load growth may be minimal due to current economic conditions. Over the long
term, however, overall load growth is expected to result in larger electricity demand in Southern
California. If in-basin generation resources are limited, a larger load demand will drive the need
for additional energy imports from outside the load basin. Additional transmission may be
required to enable such additional energy requirements to be provided from the Northern
Hemisphere.

Potential increases in RPS goals, the retirement of in-basin generation, and system load
growth may place additional constraints on transmission capacity. Any underground
configuration of Segment 8 of TRTP should be designed to double-circuit 500 kV standards in
the same manner as the Approved Route to facilitate the incremental transmission necessary to

38 See California Energy Commission, Preliminary California Energy Demand Forecast 2012-
011/CEC-200-2011-011-SD.pdf
support more generation resources from SCE’s Northern Hemisphere without additional costly
transmission upgrades in the future.

B. Planning Rationale for Maximizing Corridor Design [J. Chacon]

To preserve TRTP’s overall value at the least cost and minimal environmental impact, the
double-circuit capacity of TRTP’s overhead design approved by the Commission and CAISO
should not be altered should the Commission decide that undergrounding is warranted. Any
underground design considered by the Commission should therefore incorporate a design that
allows for double-circuit build out. As originally defined in the Project objectives, SCE would
construct TRTP in an orderly, rational, and cost-effective manner. The current double-circuit
design in the Approved Route would maintain reliable electric service by minimizing service
interruptions, during construction both now and into the future. Such planning principles
resulted in the defined double-circuit transmission design standard. CAISO recognized the
importance of such design in the CSRT-2006 Report on TRTP:

Between Vincent and the northern boundary of the City of Duarte
(adjacent to Angeles National Forest), the transmission line will be
constructed as single-circuit 500 kV specification. From this point
to the Mira Loma area, the transmission line will be constructed as
double-circuit 500 kV specifications to maximize the capability of
limited corridors and to minimize environmental impacts
associated with multiple 230 kV lines and/or multiple tear-down
and rebuild activities.\(^{39}\)

Prudent transmission planning therefore resulted in a Project design that could facilitate
further transmission expansion and minimize impacts related to future construction.
Transmission corridors through urbanized areas, such as the ROW through Chino Hills, are
extremely limited and immensely valuable. California statutory policies known as the
Garamendi Principles encourage SCE to maximize the use of these existing ROWs.\(^ {40}\) These
principles can be implemented by designing transmission upgrades in a manner that does not
needlessly block future expansion or prevent greater utilization of the corridor.

\(^{39}\) CAISO, South Regional Transmission Plan for 2006, Part II: Findings and
Recommendation on the Tehachapi Renewable Transmission Project (Dec. 29, 2006),
available at http://www.caiso.com/18db/18dbaef2cca0.pdf.

\(^{40}\) See D.09-12-044 at 19 (discussing Garamendi principles).
As shown in Figure 9a, the Commission approved transmission upgrades across the Angeles National Forest, Segments 6 and 11, with 500 kV design standards, and designed Segments 7 and 8 for double-circuit 500 kV. These design specifications facilitate future expansion of the transmission system with less disruption, because infrastructure between the Mira Loma and Mesa Substations necessary to operate the transmission line as double-circuit would largely already be in place when the further need arises.

Figure 9a
Geographic Representation of SCE’s Northern Hemisphere With Ultimate System Design Facilitated by TRTP

Figure 9b provides the one-line representation of these connections and illustrates how the design upgrades implemented by TRTP will be used to provide for the additional

41 Segments 7 and 8 will initially operate as a split-phase single circuit for electric and magnetic fields (EMF) mitigation.
transmission lines. TRTP’s Proponent’s Environmental Assessment (PEA) discussed such future transmission expansion:

TRTP will allow for future low cost network upgrades to further increase renewable resource integration beyond the TRTP estimated 4,500 MW capability. Given that the total amount of requested interconnections . . . are in excess of 4,500 MW, the use of 500 kV construction standards is prudent and will allow for installation of additional 500 kV [transmission lines] with minimal environmental impact when required. Although not part of this plan, SCE also envisions a possible future Mesa 500 kV Substation, which can only be accomplished with minimal impacts if 500 kV design specification for the new transmission construction is implemented as part of this project (both single-circuit and double-circuit).42

Figure 9b
One Line Diagram of SCE’s Ultimate Transmission Plan to Northern Hemisphere

Legend
- 220 kV (Existing)
- 220 kV (TRTP)
- 500 kV (Existing)
- 500 kV (TRTP)
- 500 kV (Future)
- 500 kV Substation (Future)

42 PEA, Tehachapi Renewable Transmission Project (Segments 4 through 11) at 1-8.
CAISO identified this future expansion in the report published in the CSRTP-2006.\(^{43}\) Overall, Segment 6 and Segment 7 would support the creation of a new Mesa – Vincent No. 1 and portion of the Mira Loma – Vincent 500 kV transmission line. Segment 8 would support the creation of a new Mesa – Serrano and complete the Mira Loma – Vincent 500 kV transmission line started by Segments 6 and 7. Segment 11 would support the creation of a new Mesa – Vincent No. 2 500 kV transmission line. It is estimated that this future expansion, which is facilitated by the current design of TRTP Segments 6, 7, 8, and 11, would further increase transmission capacity by approximately 2,500 to 3,000 MW.

Altering the design in the Chino Hills area from the approved overhead double-circuit design to an underground single-circuit design would create future challenges to accessing more generation resources from SCE’s Northern Hemisphere and needlessly complicate system expansion necessary to accommodate future generation, in-basin retirement, and increased load. Limiting Segment 8 to single-circuit capability will result in the future need for more transmission infrastructure between the point where TRTP stops being double-circuit and the Mira Loma Substation. To satisfy that future need, the second circuit would have to be routed through the urbanized areas in Chino Hills, or alternatively through the Chino Hills State Park. Future construction of the second circuit would likely result in new environmental impacts, future disruptions to the local communities, and increased cost. Delaying construction of a second circuit to some point in the future would also potentially disrupt generation resources supported by TRTP, likely resulting in prolonged curtailment. For instance, curtailments would occur if future transmission infrastructure between the point where the design stops being double-circuit and the Mira Loma Substation requires de-energization of the Mira Loma-Vincent 500 kV transmission line to allow for safe construction of future upgrades.

To avoid these limitations, prudent transmission planning dictates that any underground configuration in the Chino Hills should avoid needless hurdles to future system expansion. Such underground configuration should not limit the existing transmission corridor from being used

for the ultimate two-circuit 500 kV configuration necessary to support future load. If the Commission were to order undergrounding in the Chino Hills area, prudent planning would also warrant a double-circuit design for the transition stations to ensure the transition stations need not be rebuilt to support the ultimate system need. Doing otherwise would undermine considerations of regional transmission stability, and increase the likelihood of additional construction efforts in the Chino Hills area to install a second circuit.44

C. System Planning Requirements for the Near-Term [J. Chacon]

Continued system expansion could result in more current carrying requirements under normal operating conditions beyond the capability that can be supplied by an underground configuration that is limited to two cables per phase. As discussed in SCE’s Supplemental ACR Response, undergrounding portions of TRTP previously designed as overhead routes requires considering long-term transmission requirements.45 Underground cable configurations that do not match the thermal rating of the overhead conductor will introduce a long-term system limitation that will be much more difficult, costly, and environmentally disruptive to upgrade when additional electrical capacity is later needed. To avoid needless bottlenecks, it is good utility practice to design underground transmission systems in a way that enables the underground portion of the line to closely match the thermal normal and emergency ratings of the overhead conductor.

Based on a maximum South of Vincent flow of 8,500 MW, a “snap shot” single power flow study identified a 1,712 amps current carrying requirements under normal operating conditions and 3,455 amps current carrying requirements under emergency line loadings.46 It is important to note that a single “snap shot” power flow is insufficient to properly identify the maximum normal and emergency loading conditions associated with a broad range of load and

44 As discussed above, a design that facilitates a double-circuit 500 kV transmission line between the Mesa and Mira Loma Substations ensures that any underground configuration ordered by the Commission does not limit future use of the ROW. From a transmission planning perspective, the increased capacity provided by a double-circuit transmission line outweighs any ampacity effects resulting from two circuits buried underground adjacent to each other. See Section II.D.3.

45 Supplemental ACR Response, Section I.B, System Planning Requirements.

46 See id. at 4.
generation operating conditions. Consequently, it is appropriate to increase the normal and
emergency current carrying requirements to ensure sufficient capacity is available for a broad
range of system conditions. As part of the Supplemental ACR Response, SCE recommended
that the minimum facilities that could be installed underground be capable of at least 2,000 amps
under normal conditions and at least 3,500 amps under emergency conditions for the needs
identified for TRTP alone. The increase from 1,712 amps to 2,000 amps reflects a 15%
increase to the flow under normal operating conditions and is less than the 2,272 amp normal
identified in the Field Management Plan for the split-phase configuration evaluation. As can be
seen, the “snap-shot” power flow is variable, and thus it is inappropriate to utilize a single value
derived from a single “snap-shot.”

If the Commission decides to order SCE to underground through Chino Hills, it is
recommended that the underground configuration include a three cables per phase installation as
a means of providing mitigation to potential prolonged capacity reductions that could occur
should one of the cables fail. A third cable will also provide additional capacity for potential
future low-cost system expansion. One such potential low-cost future upgrade that could be
implemented before developing the ultimate 500 kV system upgrade described above involves
installing series compensation on the Mira Loma – Vincent 500 kV transmission line. Such
series compensation would result in providing additional incremental South of Vincent capability
by providing better utilization of the overall 500 kV transmission lines connecting to SCE’s
Northern Hemisphere. The series capacitor would force more power to Mira Loma through the
Mira Loma – Vincent 500 kV transmission line, thereby better balancing transmission corridor
utilization between South of Lugo and South of Vincent.

Preliminary review of such potential future low-cost alternative indicates that the total

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47 Id. at 5.
48 Id. at 4.
49 See infra Section II.D.
50 Series capacitors effectively reduce the overall impedance of the line making the line
electrically shorter. This reduction in impedance would result in increased line flow due to
the physics associated with the paralleled paths (i.e., Ohm’s Law).
South of Vincent capability can be increased from approximately 8,500 MW to approximately 8,900 MW, which would provide an incremental 400 MW capacity to resources in the Northern Hemisphere. However, such system transfer increase would result in increases to the flow on the Mira Loma-Vincent 500 kV transmission line. The preliminary results indicate that the flows can reach up to 3,265 amps under normal conditions. Further detailed studies will be required to define exact line loading capability for such series compensated low-cost upgrade.

Consequently, an underground alternative should not block future expansion by ensuring the design is implemented with consideration to future system needs.

D. Ampacity for Chino Hills Underground Transmission Systems

1. Introduction [P. Hlapcich]

Transmission lines must operate safely under normal and emergency load conditions. SCE requires ratings determinations for normal steady state operations as well as emergency conditions of various lengths of time (e.g., 4 hour, 1 hour, 30 minutes, and 15 minutes). For example, the 15 minute rating identifies how much current the line can carry for an emergency condition lasting 15 minutes. Likewise, if the emergency takes 4 hours to mitigate, the current on the transmission line must be within the 4 hour rating limit. Among all the emergency operation situations, the 4 hour emergency operation is the most limiting factor for a proposed cable system rating. Operating a cable system above its emergency load will cause the cable and its accessories to heat up to an unsafe and unproven temperature that could result in the reduction of the cable system design life and/or system failure.

To ensure system reliability over the long-term, SCE must analyze each underground configuration to determine whether the underground transmission cable can support the same load (ampacity) as the Approved Route’s overhead design under both normal and emergency conditions. The Approved Route rating reflects the amperage that could be transferred on the bundled 2156 kcmil ACSR used in the overhead transmission line. SCE must also analyze each underground configuration against the expected short-term carrying requirements associated with

TRTP under both normal and emergency conditions (Present Requirements). The Approved Route’s ampacity is greater than the Present Requirements.

2. Ampacity Calculations for Segment 8A [F. Rong, B&V]
   a. Ampacity Limitations of 500 kV Underground Cables
      
      Under Normal and Emergency Conditions

      The 500 kV underground cable system, if adopted by the Commission, needs to be designed for both normal steady state continuous and short time emergency operations. Depending on the system requirement, either normal steady state or emergency ampacity requirements could be the limiting factor in determining the required cable size and/or the number of cables per phase required for each circuit.

      In addition, for all high-voltage cable systems, a “Prequalification Test” (PQ Test) is used as an evaluation criteria to demonstrate satisfactory long term performance of a complete cable system prior to commercial operation. A PQ Test also shows that the cable system can be operated up to elevated conductor temperature for a specified emergency duration over the cable system’s life expectancy.

      Most electric utilities in North America, including SCE, operate their underground transmission cable to 90° Celsius (C) during normal steady state continuous conditions and up to 105°C during an emergency condition. Having the short-term ability to operate the cable at an elevated temperature provides a utility with increased flexibility and increased loading capability during an emergency condition. Because of this need, the Association of Edison Illuminating Companies (AEIC) concluded in AEIC CS9 that a complete cable system should be PQ Tested at the conductor temperature of 105°C in order to verify the cable system long term performance during emergency operation.

      Based on available information at the time this document is prepared, all existing 500 kV XLPE cable systems in commercial operation are installed outside North America, and there are no cable system suppliers that have performed the PQ Test on 500 kV XLPE cable as required by the AEIC standard. Rather, each potential supplier has performed PQ Testing on 500 kV XLPE cable systems outside North America.

      52 See Supplemental ACR Response, Section I.B, System Planning Requirements.
XLPE cable to the International Electrotechnical Commission (IEC) Standard (i.e., IEC 62067). Although it is recognized worldwide, the IEC standard does not consider the emergency operation of cable conductor temperature at 105°C used by the utilities in North America. The IEC PQ Test only requires testing the cable system with conductor temperature up to 5°C above normal operating temperature to 95°C maximum.

Installing 500 kV XLPE cable that has been PQ Tested only to the IEC standard would limit SCE to operating its cable system with conductor temperature at 95°C, rather than 105°C, during emergency conditions. To operate a cable conductor to 105°C during emergency conditions, a long-term PQ Test meeting the AEIC standard would be required. Such a test would take at least one year to complete.

b. Ampacity of One, Two, or Three Cables per Phase With Single- and Double-Circuit Configurations

The amount of load an underground transmission cable can handle varies, depending on how many cables are used to transmit each phase of an electrical circuit and whether there are one or multiple circuits in proximity to each other. B&V has analyzed the expected cable system ampacity based on 500 kV XLPE underground cable installations through Chino Hills using one, two, and three cables per phase, in single-circuit and double-circuit configurations.

B&V, in consultation with SCE, used an industry-accepted commercial software program to perform ampacity calculations for both normal steady state continuous and emergency conditions. The software program calculated the maximum limit of the electrical current that can flow through the underground cable at specified cable conductor temperature and duration.

Calculating the normal and emergency load conditions requires critical design criteria, including ambient environment and circuit installation details. The ambient environment can affect cable ampacity, based on factors such as soil ambient temperature at the installation depths and

53 As discussed above, both AEIC and IEC standards recognize that XLPE cable can be operated to 90°C under normal condition. Because each potential 500 kV underground cable supplier has only tested its cable to the IEC standard, SCE would have to limit emergency operations to 95°C rather than 105°C for the portion of the underground route in Chino Hills. Because the four hour emergency condition is the most limiting factor, the four hour/95°C emergency situation is used in each of the following comparisons.
thermal resistivity of native soil, backfill material, and duct bank concrete. How deep a circuit is buried, including whether the circuit is buried in concrete duct bank or in trenchless drill bores, can also affect cable ampacity. The ampacity calculation was performed based on multiple burial depth and construction types (i.e., duct bank or HDD). Based on preliminary engineering, these configurations included the duct bank at minimum depth (4 feet), duct bank at maximum depth (10 feet), HDD at 60 foot depth, and HDD at 100 foot depth. The results show that the HDD location at 100 foot depth provides the least amount of ampacity. This location therefore is the limiting factor for overall cable rating. Note, however, that the ampacity may change as the design continues to be refined.
Tables 3a and 3b
Underground Cable Ampacity Normal Loading Condition
(Steady State Continuous)

Table 3a
Double Circuit Normal Rating Ampacity

<table>
<thead>
<tr>
<th>Cables Per Phase</th>
<th>Normal 90°C Underground Cable System (Amps per Circuit)</th>
<th>Normal Approved Route (Amps Per Circuit)</th>
<th>Normal Present Requirement (Amps Per Circuit) (^{55})</th>
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Table 3b
Single Circuit Normal Rating Ampacity

<table>
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<tr>
<th>Cables Per Phase</th>
<th>Normal 90°C Underground Cable System (Amps per Circuit)</th>
<th>Normal Approved Route (Amps per Circuit)</th>
<th>Normal Present Requirement (Amps per Circuit) (^{56})</th>
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<td>3</td>
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\(^{55}\) See Supplemental ACR Response, Section I.B, System Planning Requirements (discussing minimum normal and emergency ampacity).

\(^{56}\) Id.
## Tables 4a and 4b
Underground Cable Ampacity Emergency Loading Condition
(4 hour Emergency)

### Table 4a
Double Circuit Emergency Rating Ampacity

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<tr>
<th>Cables Per Phase</th>
<th>Emergency 95°C Underground Cable System (Amps Per Circuit)</th>
<th>Emergency Approved Route (Amps Per Circuit)</th>
<th>Emergency Present Requirement (Amps Per Circuit)</th>
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### Table 4b
Single Circuit Emergency Rating Ampacity

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<th>Cables Per Phase</th>
<th>Emergency 95°C Underground Cable System (Amps per Circuit)</th>
<th>Emergency Approved Route (Amps per Circuit)</th>
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<td>5,330</td>
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3. Installing Three Cables per Phase Most Closely Approximates the Capacity of the Approved Route [P. Hlapcich]

Several factors must be considered in determining whether an underground configuration meets the normal and emergency load capacities of the Approved Route or the Present

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57 *Id.*
58 *Id.*
Requirement of TRTP. The significance of selecting three or two cables per phase can be viewed from a normal load condition and emergency load condition. Installing three cables per phase most closely approximates the Approved Route and provides additional redundancy in case of cable failure.

As Tables 3a through 4b show, installing three cables per phase comes closest to matching the ampacity for the Approved Route for TRTP Segment 8 under both normal and emergency load conditions. Due primarily to the mutual heating impact of two circuits installed near each other, a double-circuit, three cables per phase underground configuration would provide less ampacity than a similar single-circuit underground configuration. Installing three cables per phase in either a single- or double-circuit underground configuration provides sufficient ampacity to satisfy the Present Requirements of TRTP under both normal and emergency load conditions.

Conversely, based on Tables 3a through 4b, adoption of a two cables per phase underground configuration is problematic from an ampacity perspective both when compared to the Approved Route and the short-term Present Requirements. While a two cables per phase single- or double-circuit underground configuration would satisfy TRTP’s short-term Present Requirements under normal conditions, installing a two cables per phase double-circuit underground configuration would not meet the Present Requirements during emergency load conditions. TRTP’s double-circuit design was approved to meet the region’s long term transmission needs. A two cables per phase underground configuration would result in a transmission system that falls short of the ampacity rating of the Approved Route under normal and emergency conditions, regardless of whether SCE installed a single- or double-circuit

59 As shown in Table 3b, a single-circuit, three cables per phase configuration exceeds the ampacity of the Approved Route.

60 The July 2012 and November 2012 ACRs did not require SCE to undertake an analysis of single cable per phase underground configurations. See July 2012 ACR at 4-5; November 2012 ACR at 2-3, 8 (directing SCE to develop prepared testimony on two- and three-cables per phase underground configuration). One cable per phase for both the double circuit and single circuit configurations would be below the Approved Route and Present Requirement ratings under normal and emergency conditions.

61 See supra Sections II.A through II.C.
underground configuration. Accordingly, ampacity considerations support the installation of three cables per phase.

A potential emergency condition resulting from the failure of one cable of the underground circuit should also be considered. With three cables per phase, one of the cables can be out of service and the remaining two cables can meet the present planning emergency load projection (i.e., the three cables per phase line would temporarily be able to perform as a two cables per phase line). With a two cables per phase configuration, however, when one cable is out of service, the remaining cable would not meet the projected Segment 8 load projections under either normal or emergency conditions. Accordingly, prudent transmission planning warrants that a third cable per phase be installed, providing a redundancy to prevent a prolonged outage or reduced capacity due to cable failure.

III. DEVELOPING COST AND ENGINEERING ESTIMATES FOR THE 500 KV UNDERGROUND CONFIGURATIONS [J. Rector, B&V]

Based on SCE’s initial conceptual design, B&V was tasked by SCE to perform additional engineering and cost assessment work relating to a portion of each of the underground configurations. The engineering processes for the current design are consistent with those described in the ACR Response. B&V developed a high level cost estimate to provide an independent check of what SCE provided in the ACR Response and Supplemental ACR Response.

The portion of the engineering work that was assigned to B&V was to evaluate the scope and cost of the engineering, subsurface exploration, access road placement, site grading, duct banks, restraint vaults, splice vaults, horizontal directional drilling, earth work, cable system material, cable system installation, and construction management. Using the Supplemental ACR Response’s basic scope for the cost estimate, B&V independently developed costs for the installations, without utilizing cost data from the previous testimony. B&V developed draft written specifications that provided additional specificity to the supply and construction scope.

ACR Response, Section V.C.5, Engineering Processes Leading Towards Construction for the 500 kV Underground Alternatives.
In addition, B&V recently developed construction specifications for the duct bank construction and for the cable system in order to obtain lump sum pricing from the bidders, the responses to which are still outstanding.

With respect to design of potential underground configurations, preliminary engineering design was performed by B&V to support the assigned work. Project-specific design drawings were prepared that included plan and profile drawings, horizontal directional drill design, splicing and restraint vaults, and cable termination and transition station layout. Cable system designs were also performed. B&V worked with and reviewed the cable system study provided by PDC, which provided information for SCE’s ACR Response and Supplemental ACR Response. Site visits were conducted with construction contractors along the ROW.

The SCE portion of the engineering work consisted of the development of reactive compensation, dead end towers to transition to the overhead portion of the circuits, removal of existing foundations and poles, SCE overheads, real properties, telecommunications, distribution, environmental, and the contingency. The split of the engineering responsibility between SCE and B&V is shown in more detail in Attachment Y.

After reviewing the proposed scope, B&V validated the basic scope of SCE’s underground configurations based on the conceptual options in the ACR Response and Supplemental ACR Response. Additional scope was identified and defined as the work progressed and incorporated into the current estimates for each underground configuration. B&V anticipates that the cost and design of the underground configurations will continue to evolve as more information becomes available. B&V also provided additional scope definition so SCE could assess whether to reduce the contingency for each underground configuration.

With regard to costs of potential underground configurations, SCE retained B&V to help develop a full project cost estimate with independent input. B&V was responsible for developing the engineering, procurement, and construction costs for an underground transmission line, including grading and duct bank construction in the transition stations. SCE was responsible for estimating costs for the cable termination structure, overhead conductor takeoff structure inside the transition station and connection to the overhead transmission lines.
SCE was also responsible for estimating costs for demolishing existing SCE structures, the
addition of shunt reactors at the Mira Loma and Vincent substations, protection and control
requirements, information technology additions, purchasing real estate and ROW, sub-
transmission and distribution responsibilities, environmental monitoring and mitigation, SCE
project management, engineering and in-house support, SCE internal costs, and contingency.
B&V’s cost estimates generally confirm the magnitude of underground costs previously
estimated by SCE. B&V also independently confirmed that SCE’s 50% contingency was
reasonable given the early stage of the cost estimate and the need for further engineering and
studies.

IV. SUMMARY OF ESTIMATED COSTS [D. Heiss]

A. Costs to Date on Segment 8 East

Pursuant to Commission direction, SCE has revised preliminary cost estimates for
underground configurations for TRTP in the Chino Hills area. These costs are in 2012 constant
dollars.63 Before presenting the preliminary cost estimates, the following provides the costs-to-
date for the Project—as approved by the Commission—in the Chino Hills area.

As of November 2011, SCE has spent approximately $61 million to construct the portion
of Segment 8A through Chino Hills using SCE’s existing ROW. These costs include the costs of
(1) removing the existing 220 kV transmission structures, (2) designing the new structures,
(3) constructing the new structures, (4) implementing the environmental mitigation measures
required by the Final Environmental Impact Report (Final EIR), and (5) installing the 500 kV
upgrades at the Mira Loma Substation. SCE estimates the remaining costs to complete the
approved overhead design through Chino Hills to be $100 million, which means that the total
forecast for this portion of the Project is estimated at $161 million.64 This estimate is constant

63 Previously submitted testimony regarding costs was in 2011 constant dollars. Because of
escalation between the years, these cost numbers differ slightly from those previously
presented in the January 2012 ACR Response, which used 2011 constant dollars.

64 These dollar amounts exclude corporate overheads. SCE acknowledges that these cost
numbers slightly differ from those presented in SCE’s Response to Chino Hills’ Petition for
Modification, filed November 28, 2011. The changes to the cost estimates are minor and are
based on a more refined analysis since the November 2011 filing. SCE also acknowledges
for each of the underground configurations discussed below.

**B. Comparison of Estimated Construction Costs for Underground Configurations**

Table 5 compares the total estimated costs associated with each underground configuration, including the Approved Route. Table 5, Column J (Total Cost (w/o future scope)) represents the total estimated cost of completing Segment 8A (or modified route) for each identified underground configuration in its entirety. That is, the estimated total cost includes both (1) the cost to construct the specific underground configuration, and (2) the costs associated with completing the construction of the rest of Segment 8A (i.e., the portions of Segment 8 west and east of Chino Hills). This allows a comparison of the incremental costs between the Approved Route and all of the identified underground configurations in this Preliminary Underground Testimony.

SCE has included the costs necessary to complete the remainder of Segment 8A in Column I (Approved Route’s Costs to Go) separate from the construction of each identified underground configuration. For Segment 8A’s Approved Route, the Costs to Go include costs associated with the installation of structures from M57-T4 to M60-T3 and from M64-T2 to M73-T5, as well as the installation of ten structures required to accomplish 220 kV crossings. SCE has estimated these Costs to Go at $106 million, an estimate that is constant for each of the underground configurations.\(^{65}\)

Sections VI and VII explain the scopes of the various underground configurations. Importantly, each underground configuration may not be comparable in scope, since each may have a different capacity or orientation. The estimates developed for the underground configurations in this Preliminary Underground Testimony are preliminary and based on a conceptual scope. A separate regulatory filing with more detailed scope and updated cost estimates would be appropriate if the Commission adopts an underground configuration in this proceeding that differs from the Approved Route. The costs illustrated in Table 5 are neither

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\(^{65}\) This Costs to Go estimate includes corporate overheads.
The portion of inception-to-date recorded costs that would be abandoned if the Project’s approved overhead route does not go forward is approximately $16 million. The costs spent to erect these structures would essentially be wasted. Should the approximately 3.5 miles of work within Chino Hills not be completed as approved, the structures built to facilitate that work within the Approved Route would have to be removed, since they would be unnecessary for and conflicting with any underground configuration. At this stage of engineering, the abandoned costs are anticipated to be the same for each of the underground configurations. The $16 million breakdown of abandoned costs is equal to the costs spent to date within MP 21.8 to MP 25.6 and breaks down as follows:

- $8M for construction completed to date;
- $3M for associated project support (including environmental monitoring);
- $4M for associated material; and
- $1M for environmental mitigation of foundations already completed.

In addition to these abandoned costs, for each of the underground configurations, removing the already-constructed overhead infrastructure would cost approximately $2 million.67

To provide the estimated environmental costs for underground configurations in the ROW, the known costs to date for Segment 8 environmental costs were calculated as a percentage of construction costs. The Project-to-date average environmental costs as a percentage of construction costs are 26% for Segment 8. The known cost increased from the previously estimated 20% after experience and further consideration of potential impacts to environmental resources.

The final environmental costs will be a function of actual resource impacts and the demand of the construction schedule. For each underground configuration, potential additional impacts to environmental resources may occur due to: (1) additional demolition, ground disturbance, and truck traffic; (2) roadway lane closures; (3) proximity to residences;

66 This figure excludes corporate overheads.
67 This calculation excludes corporate overheads.
(4) different construction activities (trenching and directional drilling) than previously used in the ROW, including potential for night construction; and (5) potential accommodations for water resources/features and recreation facilities.

### Table 5
**Estimated Costs**

<table>
<thead>
<tr>
<th>$ in Millions (2012 Constant Dollars)</th>
<th>ITD(^{68}) recorded Costs</th>
<th>Costs to go</th>
<th>Corp OH</th>
<th>Total Cost (w/o future scope)</th>
<th>Estimate Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useable</td>
<td>To Abandon</td>
<td>Total</td>
<td>Removal</td>
<td>Install</td>
<td>Contingency</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>C,A+B</td>
<td>D</td>
<td>E</td>
<td>F=(D+E)*Cont%</td>
</tr>
<tr>
<td>Approved Route 15% Contingency</td>
<td>61</td>
<td>0</td>
<td>61</td>
<td>0</td>
<td>87</td>
</tr>
<tr>
<td>Underground Configurations 50% Contingency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UG1</td>
<td>46</td>
<td>16</td>
<td>61</td>
<td>0</td>
<td>397</td>
</tr>
<tr>
<td>UG2</td>
<td>46</td>
<td>16</td>
<td>61</td>
<td>0</td>
<td>279</td>
</tr>
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<td>46</td>
<td>16</td>
<td>61</td>
<td>0</td>
<td>245</td>
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<td>UG4</td>
<td>46</td>
<td>16</td>
<td>61</td>
<td>0</td>
<td>229</td>
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<tr>
<td>UG5</td>
<td>46</td>
<td>16</td>
<td>61</td>
<td>0</td>
<td>195</td>
</tr>
</tbody>
</table>

Attachment Z provides an itemized breakdown of the costs in Column G of Table 5 for each underground configuration. Attachment AA provides further breakdowns by

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\(^{68}\) ITD refers to Inception to Date.

\(^{69}\) HMC refers to Home Office Material Construction.
Labor/Equipment and Materials.\textsuperscript{70}

C. Contingency

Both the Association for the Advancement of Cost Engineering (AACE)\textsuperscript{71} and the Electric Power Research Institute (EPRI) propose guidelines for setting contingency. In addition to considering AACE’s and EPRI’s guidelines, SCE bases its contingency standards on the professional judgment and experience of SCE’s engineering and construction staff.

Table 6 summarizes SCE’s contingency assumptions and shows that its assumptions are reasonable relative to industry accepted standards. Column K of the Estimated Costs Table above correlates the estimate class with contingency guidelines in Table 6 below. SCE’s class 5 cost estimates for the undergrounding configurations include a reasonable industry accepted standard contingency assumption of 50% based on the fact that the scope is at a feasibility level.

Based on the additional scope definition provided by B&V, SCE determined that the contingency provided in the Supplemental ACR Response could not be reduced based on available information. Several factors drive the 50% contingency. First, trenching and trenchless installation estimates are not based on geotechnical boring and engineering analysis of the borings. The soil sampling was recently completed, but not in time to be included in these cost estimates. During construction, SCE could encounter rock or difficult material, unstable conditions, contaminated soil, or other geotechnical issues that could result in significant alignment modifications or alternative construction methods. Further trenching details need to be assessed, and SCE must conduct underground utility research and surveys, investigate flood control permitting, and assess permissible impacts to city streets and traffic.

Second, SCE must develop further details regarding cable infrastructure requirements. Based on the selected cable design, SCE must better define the type and number of restraint vaults and size of splice manholes.

Third, environmental impacts have not been finalized, and mitigation measures may be required based on the proposed construction methods. Construction work hours and restrictions

\textsuperscript{70} The figures in Attachments Z and AA are preliminary and subject to change.

\textsuperscript{71} Formerly known as the American Association of Cost Engineers (AACE).
need to be understood, which could depend on the actual design and construction schedule. As the Project nears construction, SCE must refine material handling and storage requirements. Finally, material supply costs and risk will be impacted by price escalation, supplier liability acceptance, supplier cable qualification test success, cable transportation risk, and cable storage damage risk. The availability of qualified splicing technicians and in-service testing failures will impact cable installation. Substation impacts include additional station equipment upgrades that may be required due to required station modifications. Additional land will need to be procured for transition stations, which could affect overall Project cost.

### Table 6
Application of Contingency

<table>
<thead>
<tr>
<th>SCE Project Stage</th>
<th>Contingency Assumption</th>
<th>Estimate Class/Usage</th>
<th>Potential Overrun</th>
<th>Project Stage</th>
<th>Suggested Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Planning</td>
<td>40-50%</td>
<td>Class 5/Screening or Feasibility</td>
<td>40-200%</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Conceptual/Preliminary Plan (CPCN Filing w/Optional Scopes)</td>
<td>30-40%</td>
<td>Class 4/Concept Study or Feasibility</td>
<td>30-120%</td>
<td>Simplified Estimate</td>
<td>30-50%</td>
</tr>
<tr>
<td>Licensed Project (Selected Scope)</td>
<td>15-25%</td>
<td>Class 3/Budget or Control</td>
<td>20-60%</td>
<td>Preliminary Estimate</td>
<td>15-30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class 2/Control or Bid</td>
<td>10-30%</td>
<td>Detailed Estimate</td>
<td>10-20%</td>
</tr>
<tr>
<td>Final Engineering Design Spec</td>
<td>10-20%</td>
<td>Class 1/Bid or Check Estimate</td>
<td>10%</td>
<td>Finalized Estimate</td>
<td>5-10%</td>
</tr>
</tbody>
</table>

* AACEI International Recommended Practice No. 17R-97, 2003

**EPRI, Technology Assessment Guide, 1993
V. REVENUE REQUIREMENT OF UNDERGROUND CONFIGURATIONS

[S. Peters]

A. Purpose of the Present Value Revenue Requirement

The cost of any initial reduced scope (single-circuit) underground configuration cannot be directly compared to the cost of the Approved Route. Any reduced scope underground configuration will eventually be required to be built out to meet the capacity of the Approved Route, which was designed and approved as a double-circuit line to help satisfy the region’s long-term demands. To accurately measure the cost to ratepayers, a method is therefore needed to compare the cost of incremental transmission investment over time with the cost of the Approved Route.

A Present Value Revenue Requirement (PVRR) is used to convert the ratepayer revenue required to repay an investment over its life into a common basis in current-year dollars. To determine whether any underground configuration is cost effective, the cost of each underground configuration should be converted to a PVRR reflecting all future underground upgrades necessary to build out the underground configuration to the final double-circuit design. Each PVRR can then be compared to the PVRR of the Approved Route to determine the ultimate cost that ratepayers will incur.

B. Conversion of Costs into a Revenue Requirement

SCE incurs costs, and customers pay revenue requirements, over a number of years. SCE must therefore calculate a revenue requirement for each underground configuration that customers would expect to pay over time. SCE’s revenue requirement—or cost of service—equals the sum of all costs necessary to meet SCE’s obligation to serve ratepayers. This includes all of its operating expenses, depreciation expenses, tax expenses, and a return on its investment, as expressed by the following formula:

72 See supra Section II.

73 In addition to the total Project cost, the ratepayer revenue requirement calculation should include CWIP in Ratebase and/or AFUDC, return and taxes, impacts of lost bonus depreciation, analysis of replacement energy, impact of curtailment costs on ratepayers, and other relevant analysis.
Revenue requirement = Operations and Maintenance (O&M) expense + Depreciation expense + Tax expense + Return on investment

The O&M expense is the cost of routine work that SCE performs to supply electric service during the course of a year. O&M expenses include labor, materials, supplies, and variable administrative and general (A&G) expenses. The depreciation expense is the charge against earnings that SCE takes each year to allow for the recovery of an investment (including removal costs) over its useful life. The tax expense includes taxes based on income, miscellaneous taxes, and ad valorem (property) taxes on incremental investments.

Finally, the return on investment is the cost of capital that SCE incurs to finance its long-term investments. To calculate its return on investment, SCE multiplies its incurred long-term investment by the cost of capital. SCE’s incurred long-term investment is its rate base. The following formula describes the calculation of rate base:

\[
\text{Rate Base} = \text{Fixed capital} - \text{Reserves}
\]

Fixed capital is the sum of (1) the plant in service; (2) the intangible plant, including capitalized software; and (3) plant held for future use. Reserves include accumulated depreciation, accumulated amortization, and accumulated deferred taxes. For the cost-effectiveness analysis of the underground configurations in the Chino Hills ROW, SCE will use its incremental cost of capital.

C. Conversion of the Revenue Requirement into a Present Value

Once SCE has calculated the revenue requirements for each cost component, it is necessary to put the revenue requirements on a consistent basis relative to the timing of the customers’ payments. This is done by combining the streams of revenue required over the years into a single present value.

The difference between the sum of the annual revenue requirements and the PVRR is due to the timing of the customers’ payments. The earlier the customer pays the revenue requirement, the higher the present value. The following formula translates the revenue
requirement into the present value:

$$PV = \frac{RR}{(1 + r)^1} + \frac{RR}{(1 + r)^2} + \ldots + \frac{RR}{(1 + r)^n} = \sum_{i=1}^{n} \frac{RR}{(1 + r)^i}$$

where:

- $RR$ - represents the revenue requirement costs.
- $i$ - represents the year in which customers pay the revenue requirement.
- $n$ - represents the year considered.
- $r$ - represents the discount rate.

SCE has not yet calculated the PVRR for each underground configuration because the PVRR modeling requires an accurate measure of costs incurred over the time of construction. Once SCE has the material supply and construction costs spread over time from the suppliers, a PVRR model for each underground configuration will be provided. SCE intends to include the PVRR data in its upcoming February 28, 2013 testimony for an accurate comparison of each underground configuration with each other and the Approved Route.

VI. DEVELOPMENT OF UNDERGROUND CONFIGURATIONS IN CHINO HILLS

[C. Adamson]

SCE has developed a scalable full underground configuration (Full Configuration) that most closely approximates the capacity of the Approved Route, referred to as UG1. Consistent with the July 2012 ACR, SCE also is developing design and cost information for various iterations of the Full Configuration to accommodate single- and double-circuit and two and three cables per phase configurations, referred to as UG2, UG3, UG4, and UG5, that are discussed in more detail below. Developing information about the Full Configuration at this time allows SCE to develop detailed engineering and potentially reduce cost contingencies for each underground configuration. It also assists SCE in ensuring that the existing ROW may be fully utilized.

During preparation of TRTP’s Final EIR in 2008, SCE evaluated an underground route
through Chino Hills described as the “Partial Underground Alternative 5” (Alternative 5). At that time, the preferred technology to underground 500 kV transmission lines used a gas insulated line (GIL) constructed in a tunnel. Alternative 5 contemplated using GIL in the existing ROW in Chino Hills.

The November 10, 2011 Assigned Commissioner Ruling (November 2011 ACR) required SCE to analyze and prepare testimony on additional routing and technology options for Segment 8, including any previously analyzed alternatives with refreshed data. The testimony was contained in SCE’s ACR Response served January 10, 2012. Based on developments in the industry, SCE learned that using XLPE cable, either installed in conduit or directly buried underground, could be more cost effective than GIL technology. SCE’s ACR Response therefore explored several conceptual XLPE designs (Options 6-9), each of which were designed for double-circuit, three cables per phase operation to approximate the capacity of the approved overhead design.

After SCE served its initial ACR Response, SCE was ordered to provide cost estimates for six additional underground options (later named Options 10 through 15). For Options 10 through 15, SCE developed various engineering designs to evaluate whether lower cost solutions with reduced scopes could still accomplish TRTP’s objectives. Designs of underground options with single-circuit and one, two, and three cables per phase subsets of the previously explored options were served in SCE’s Supplemental ACR Response on February 1, 2012. The Supplemental ACR Response also included testimony on feasibility, scheduling, and the cost of the various options. After serving the Supplemental ACR Response, certain parties expressed concern over the 50% contingency level that was based on a conceptual level of engineering. The contingency as a percentage of the estimated cost may be reduced only after more detailed and refined engineering is completed and bids from suppliers and construction contractors are obtained. Starting in May 2012, SCE continued the engineering process by retaining B&V to begin engineering a more refined configuration for the proposed underground section in Chino Hills. This Preliminary Underground Testimony is based on additional engineering conducted

74 See Final EIR at 2-100 to 2-111 (discussing Alternative 5).
by B&V.

Estimating cost with a lower percentage of contingency requires SCE to complete the engineering to a level required for contract bid specifications, and to bid the material and construction out for contract. To complete engineering at this level, SCE has completed geotechnical soil sampling and analysis along the route, and B&V has developed design and bid specifications. SCE is currently out to bid for the material and construction of the cable portion of the underground configurations. To manage the risk of delay to the first circuit’s completion should the Commission order SCE to underground the portion of TRTP in Chino Hills, SCE’s current approach assumes that the cable would need to be contracted by second quarter of 2013 and would proceed with material manufacturing and construction immediately after a modified CPCN decision early in the third quarter of 2013. SCE is continuing to work with the consultants and vendors to better understand these issues.

To maintain the schedules outlined in this testimony, the physical configuration of infrastructure in the ROW must be determined approximately one year before cable manufacturing and construction can start. A change in the physical characteristics or design during the Commission’s evaluation of Chino Hills’ undergrounding request would require additional time to redo the design drawings and specifications and re-bid the construction contracts. To reduce the risk of delay, SCE has developed a complete double-circuit, three cables per phase design (Full Configuration), as well as a number of alternate configurations that would incorporate a phased approach in expanding the transmission infrastructure in the Chino Hills ROW to eventually approximate the overhead capacity of the Approved Route.

VII. REVISED UNDERGROUND CONFIGURATIONS IN CHINO HILLS

A. UG1 or “Full Configuration”: Underground Double-Circuit XLPE with Three Cables per Phase in Conduit in the Existing Chino Hills ROW (Functionally Equivalent to Option 6 in ACR Response)

1. Description [P. Hlapcich]

UG1 is a double-circuit transmission line and consists of installing three XLPE cables per phase in duct bank in the existing ROW in the Chino Hills area. UG1 also requires building two
transition stations, approximately 155 feet by 235 feet (~1 acre) in size, for the cable
terminations, lightning arresters, switches, and possibly other equipment. An underground
distribution line may be required to power equipment in the transition stations. Shunt
compensation reactors located in existing substations will be required.

In total, UG1 will require 360,000 feet of 5000 kcmil XLPE cable, 288 cable pulling
segments, 90 splice vaults, 270 splices, 36 terminations, 10 restraint vaults, 30,560 linear-feet of
duct bank, 17,400 linear feet of HDD installation, and approximately 90,000 cubic yards of soil
excavation.

UG1 is a full installation of the Full Configuration and is the functional equivalent of
Option 6 described in the ACR Response. Undergrounding configurations UG2 through UG5
are various implementations of UG1.

**Cable Size and Configuration:** Primary components of UG1’s XLPE system would
likely include the following for each circuit: (1) nine cables constructed with 5000 kcmil
segmental copper conductor with XLPE insulation and metallic moisture barrier, (2) nine splices
at each vault cluster, (3) link boxes with sheath voltage limiters or ground connection at every
splice vault, (4) cable racking and clamps in each splice vault, (5) dielectric fluid filled
terminations, and (6) lightning arresters. Additional equipment would be installed at both
transition stations.

The XLPE cable has an outside diameter between 5.5 to 6 inches, and weighs about 26
pounds per foot. Each circuit will have a total of twelve 8-inch schedule 40 polyvinyl chloride
(PVC) conduits, three 2-inch schedule 40 PVC conduits, and two 4-inch schedule 40 PVC
conduits encased in a concrete duct bank. However, only nine of the twelve 8-inch ducts will be
filled with cable with the other 8-inch ducts as maintenance spares. The 2-inch ducts are used
for installing ground continuity conductor and the 4-inch ducts are for fiber optic cables.

**Route Details:** UG1 would utilize the existing SCE ROW in Chino Hills. SCE would
install an approximately 3.5-mile portion of the Project underground in the Chino Hills area.
Specifically, the Project would shift from overhead to underground at approximately Mile Post
21.9, located on a hill just south of Eucalyptus Avenue and approximately 1,000 feet east of
Canon Lane, and would continue underground through Chino Hills to approximately Mile Post 25.4, located just west of Pipeline Drive, where the underground line would shift back to overhead.75

Approximately every 1,500 feet along the route, three sets of splice vaults would be installed per circuit. As shown in Attachment BB, the splice vaults can sometimes be staggered with two vaults side by side and the third vault in front of the two side by side vaults. Each circuit would require its own set of three splice vaults. The approximate area requirement of the staggered six sets of vaults for two circuits is 95 feet long by 66 feet wide. If the ROW does not allow for the vaults to be staggered, the vaults will need to be installed next to each other. As shown in Figure 1b, a non-staggered orientation would require an installation approximately 90 feet wide, which would place the outermost vaults approximately 30 feet from the edge of the ROW.

Access roads for construction and maintenance will be required both on and off the existing ROW.

**Installation of UG1:** UG1 likely would result in the following construction and installation activities: (1) construction of the duct bank systems and two transition stations; (2) pulling of the cables from one vault to the next; (3) installation of splices, terminations, sheath voltage limiter, ground conductors, surge and lightning arrester inside the transition stations; and (4) performing commissioning tests. Shunt compensation reactors likely will be installed at the Mira Loma and Vincent Substations. The existing ROW is not suitable for the transportation of heavy cable reels, vaults, or equipment, and the construction of access roads for the transportation of heavy equipment as well as for maintenance will be required along the length of the route.

**Duct Bank Systems:** UG1’s duct bank systems would be comprised of two separate sets of duct bank, one for each circuit. A duct bank is comprised of twelve (12) 8-inch schedule 40 PVC ducts arranged to 12-inch centers, three 2-inch schedule 40 PVC ducts placed on top of the

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75 The location of the transition stations may ultimately change based on changes due to final engineering. Based on recent design work, the transition station may move to just east of Pipeline Drive.
8-inch ducts, and two 4-inch schedule 40 PVC ducts placed to the side of the 8-inch ducts. These conduits are encased in a high-strength concrete duct bank with backfill material specially designed to efficiently transfer heat away from the cables. The dimension of the ducts encased in concrete is approximately 90 inches wide by 30 inches high. The depth from grade to top of encasement is 48 inches minimum, and may vary along the route.

To install these duct banks, several hundred feet of trench would first be excavated. Twenty foot lengths of the PVC conduits would be glued together, and the duct bank assembled using duct spacers at 5-foot intervals, which is a time-consuming task. An on-site inspector must be present to witness that the conduits and conduit joints are installed correctly and free of foreign material that may damage the cables. Afterward, a cement truck slowly drives by the trench opening and pours high-strength concrete into the trench, enough for at least three inches of encasement for all of the outside conduits. Several feet of thermal backfill is then poured into the trench above the concrete duct bank to ensure uniform thermal soil property around the cable circuits. Afterward, the original soil is compacted back into the trench to the proper grade if the original soil has suitable thermal properties.

Certain areas in the ROW have a greater slope, or require placing cable under existing infrastructure, and would therefore require either HDD or a restraining vault (larger slopes create instability of the cable and the cable would creep downhill during thermal expansion and contraction causing displaced splices, which would lead toward splice failure). This approach would require six bores approximately 36 inches in diameter each, spaced 20 feet on center. The HDD bores are installed much deeper than the trench. There are some areas where the slope is greater and the terrain does not allow directional boring. These areas would require additional restraint vaults.

Because of concerns over shipping weight restrictions limiting the amount of the cable that can be transported, a vault would be placed approximately every 1,500 feet to facilitate the splicing of different sections of cable together. The splice vault has an external dimension of 38 feet long by 10 feet high by 10 feet wide and comes in five sections. Each section weighs approximately 25,000 to 30,000 pounds. To install these vaults, SCE must excavate a hole at
least 45 feet long by 15 feet deep by 12 feet wide. Heavy cranes would be utilized to lower the individual sections into the vault pit, ensuring that all seams line up and form a tight seal.

**Transition Stations:** Transition stations are required at each end of the underground XLPE cable systems. The transition station consists of cable terminations, surge arresters, switches, overhead conductors, and structures to support them. The transition station will also require permanent access, be fenced, and include a small control building to house monitoring and protection equipment to support normal operation of the circuits. Both the east and west transition stations will have a dimension of approximately 155 feet by 235 feet, or nearly an acre.

**Cable Pulling:** Approximately 288 reels of cable are required for the installation of UG1, that would be transported from a SCE storage yard to the ROW in Chino Hills. Each reel, holding approximately 1,550 feet of cable, is approximately 13 feet in diameter by 8 feet wide, and weighs approximately 45,000 pounds. Because of the size and weight, only one reel at a time can be transported on a truck. The cable reel will be loaded onto a reel stand located adjacent to the vault (the feed point). A pulling winch is located in the vicinity of the next vault (the pull point). The pulling winch slowly pulls the cable from one vault to the next. This operation is repeated for all of the reels of cable. Splicing of the cables is generally started after the cable has been pulled between several splice vaults.

**Cable Accessories Installation:** Installation of the cable accessories is critically important. The accessories include splices, terminations, grounding conductors, cable supporting and restraining hardware, and link boxes with sheath voltage limiters. The most critical and labor intensive work is on the splices and terminations. In fact, the work is so critical that cable manufacturers recommend building a temporary clean room to make cable splices. Likewise, scaffolding will be erected at the transition stations and temporary shelters put up so that the terminations can be installed without being contaminated from the external environment. Three splices or terminations take approximately seven to twenty days to complete. Because of the level of complexity of the work, one manufacturer suggested that no more than two crews be used on the same job.
**Operation and Maintenance:** There are no available installed project examples to assess the operating life of 500 kV XLPE cables. The projected and designed 500 kV XLPE cable life, however, is 40 years. This projection assumed that the various industry specifications are followed, installations are performed error free, and routine maintenances are performed on the system. As 40 years of operation approaches, SCE would need to perform an evaluation of the underground system to determine if the cable and subsequent accessories must be replaced. Qualified electrical workers must routinely inspect the system to ensure the structural integrity of that vault as well as the cable and splice supports. Furthermore, the ROW must be routinely patrolled for intrusions and potential dig-in.

In addition to routine check and maintenance to the vaults, SCE’s qualified electrical workers must also check on the condition of the sheath voltage limiters, grounding connection, splices, terminations, corrosion of the metallic supports and restraints and condition of the cable. From time to time, a jacket integrity test is performed on the cable. This is accomplished by applying minimum 10 kV direct voltage across the cable jacket for one minute. The test equipment will trip out if the cable jacket has been damaged. If cable damage is identified, the cable must be exposed by excavating the surrounding material, and the cable repaired.

**Changes as a Result of Further Engineering:** Currently, B&V is performing additional engineering to the underground alignment to produce a more accurate cost estimate for underground configurations in the Chino Hills area. This additional engineering will allow B&V to determine a more accurate depiction of the underground route alignment, placement of vault cluster locations, access road construction, directional drilling location, the size of transition stations, and overall cost. For example, the transition stations described in this Preliminary Underground Testimony are both less than one acre each. However, after factoring in the spacing requirement for the components and for maintenance, early indications from B&V’s additional engineering work suggest that the size of each transition station could increase. The west transition station is currently expected to require 2.4 acres, while the east transition station is currently expected to require 3.2 acres.
2. Engineering and Technical Feasibility [P. Hlapcich]

UG1, the Full Configuration, should be technically feasible. Because of the hilly terrain of the ROW in Chino Hills, and the need to cross under existing facilities such as streets and flood control channels, SCE must use HDD through certain areas. At the locations requiring HDD, the cables will be buried much deeper than other portions where open cut and trenching is used. At lower depths, heat caused by the loading of the cable dissipates more slowly.

Preliminary ampacity calculations based on cable ratings, soil conditions, and the length and depth of the HDD sections are provided in Section II. D. Additionally, the transition stations would require an expansion of the existing ROW for the fenced footprint of each station plus the grading requirements.

UG1 represents the eventual double-circuit facilities matching the same requirements as the Approved Route. UG1 is not desirable for full implementation at this time, however, because the cables for the second circuit are not required in the near term. Installing and energizing the second circuit cables would require additional reactive compensation when the second circuit is connected in the final termination location. UG1 is provided to describe the full build-out and to provide a cost comparison for facilities equivalent to the Approved Route.

3. Environmental Issues [J. Leung]

The amount of construction activities and the seasonal timing of the activities, as well as the underground configuration ordered, could result in greater or lesser impact and will be better understood as additional information is developed. However, the following is a preliminary assessment of potential environmental impacts associated with underground construction in the event the Commission orders undergrounding of the overhead transmission line.

Cultural resources not eligible for listing in the National Register of Historic Places/California Register of Historical Resources are located within the Chino Hills ROW. Additionally, cultural resources that have not yet been evaluated for eligibility are located adjacent to but outside the current engineered Project footprint. If the engineering changes or the construction contractor requires an area that potentially impacts a known or newly discovered cultural resource, or a resource that may be found along areas that have not been previously
surveyed, preconstruction testing and evaluation of the resource(s) will be required. If the resource is found to be eligible for listing, implementation of additional mitigation measures will be necessary. Furthermore, if significant paleontological resources are found during ground-disturbing activities, implementation of additional mitigation measures will also be required.

Public recreation areas within and adjacent to the ROW may be affected by undergrounding construction and operation. During construction, access to and use of local recreation areas may be limited or facilities may be closed due to the presence of construction materials, equipment, and activities. During operation, access to public facilities may be also limited. The extent of the limitation would be determined based on final engineering and SCE policies and procedures.

Local and regional roads would see increased traffic consistent with construction activities. The timing and duration of the increased traffic would be dependent on the construction approach and schedule.

Riparian habitat occupied by nesting least Bell’s vireo is located in a detention basin located within the ROW and concrete-lined channel adjacent to the ROW. Additionally, there are several natural and man-made drainage features within and adjacent to the ROW.

Environmentally sensitive areas known within the ROW are shown in Attachment CC. Modification of the Project description, such as changes to permanent and temporary impacts to riparian habitat, may be inconsistent with analyzed Project effects to threatened and endangered species protected under the Endangered Species Act and may require an amendment to the Biological Opinion and Incidental Take Permit. Potential impacts to jurisdictional waterways may require an Individual Permit (IP) from the U.S. Army Corps of Engineers (USACE) for permanent impacts of greater than 0.5 acres to waters of the United States. It is anticipated that an IP could be obtained from the USACE in about 14 to 24 months. In

76 Attachment CC, Environmentally Sensitive Area Figures.

77 See ACR Response, Section IV.B.3, Clean Water Act Permitting; Supplemental ACR Response, Section III.B.3, Regulatory Issues (discussion of Clean Water Act permitting).
addition, amendments to the Section 401 Water Quality Certification and Streambed Alteration Agreement would be likely be required, which would likely take three to six months to obtain.\textsuperscript{78}

4. Permanent Land Use Impacts [M. Quiroga]

SCE’s existing ROW through Chino Hills is 150 feet wide. Separate easements grant SCE the ROW through Chino Hills, each containing similar language. The easement language grants SCE the right, among other things, to construct, reconstruct, maintain, operate, enlarge, improve, repair, and remove an overhead electric transmission line within the ROW. Each easement is intended to be held in perpetuity and support electric operations over the long-term, and SCE intends that the easements will continue to serve electricity transmission and distribution operations as technology advances and improvements occur over time. Given that the Commission could order SCE to change the scope of Segment 8A from overhead to underground 500 kV facilities, SCE may have to upgrade the existing easements through the proposed route and obtain underground rights to accommodate the change in scope through negotiation, condemnation, or other means.\textsuperscript{79}

Existing land uses located within SCE’s ROW in Chino Hills may also be permanently impacted. These land uses are considered to be secondary land uses, or uses of the ROW for purposes other than electric and telecommunication utilities. Several years ago, SCE updated its secondary land use policy to no longer authorize new high-intensity uses or permanent structures on SCE ROW because such uses and structures could impede SCE’s ability to quickly access transmission and telecommunication infrastructure in the event of emergencies or for routine inspection and maintenance. The secondary land use policy enables SCE to operate, maintain, and inspect its transmission and telecommunication system in a safe, efficient, and reliable manner, consistent with SCE’s primary responsibility to provide safe and reliable electric power to its customers.

Although SCE’s secondary land use policy does not specifically address underground

\textsuperscript{78} Id.

\textsuperscript{79} It is important to note that SCE’s time estimates do not account for a prolonged property acquisition process for any necessary upgraded property rights. Delays to project completion may occur if any necessary upgraded property rights are not acquired in a timely manner.
transmission lines, it is anticipated that there may be restrictions on land use in the ROW post-construction to allow SCE to operate and maintain the underground transmission infrastructure and access the ROW in a safe manner. SCE evaluates existing secondary land uses on a case-by-case basis to ensure that each use will not interfere with SCE’s ability to operate, maintain, and inspect its transmission and telecommunication facilities. SCE’s evaluations are premised on the understanding that the primary purpose of SCE’s transmission line ROWs is to house SCE’s electrical system and related facilities, and to provide adequate space to operate and maintain those facilities in a safe and reliable manner. The evaluation will determine if the existing use is acceptable, or if the use should be modified to prevent interference with SCE’s ability to operate, maintain, or inspect its facilities. However, SCE is committed to working cooperatively with Chino Hills and other existing users. Further investigation into the secondary land uses in the ROW through Chino Hills will be required if an underground transmission configuration is utilized.

5. **Timing [C. Adamson]**

Under a best case scenario based on a number of optimistic assumptions, the timing for UG1 likely would place the first circuit in-service in January 2016, and the second circuit in-service in 2020 or later, as needed. This schedule is subject to change in the testimony to be submitted on February 28, 2013 after additional information is available. The schedule for UG1 is provided in Attachment DD.80

6. **Estimated Construction Costs [D. Heiss]**

The estimated total construction cost of UG1 amounts to $807 million, which is $635 million more than the $172 million estimated total cost of the Approved Route. This $807 million includes the cost to remove previously constructed structures, construct underground portions, complete the construction of the rest of Segment 8A, and the ITD costs that include $16 million of cost spent to date, which would be abandoned.81

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80 Attachment DD, Preliminary Underground Schedules at 1-2.
81 See supra Table 5, Estimated Costs.
7. EMF Considerations [G. Sias]

SCE uses a computer program called “MFields” to model the magnetic field characteristics of various transmission design options. All magnetic field models and the calculated results of magnetic field levels presented in this testimony are intended only for purposes of (1) identifying the relative differences in magnetic field levels among various transmission line design alternatives under a specific set of modeling assumptions and (2) determining whether particular design alternatives can achieve magnetic field level reductions of 15% or more. The calculated results are not intended to be predictors of the actual magnetic field levels at any given time or at any specific location if and when the Project is constructed.

Typical two-dimensional magnetic field modeling assumptions applied throughout this testimony for each underground configuration include:

- All transmission lines were modeled using forecasted peak loads presented in the Field Management Plan (FMP) filed in 2007. For underground configurations in which loads were split among multiple conductors, load values were divided evenly and rounded accordingly.
- The predominant design for each underground configuration was used for this analysis.
- All conductors were assumed to be straight and infinitely long.
- All underground conductors were assumed to have no sag.
- Magnetic field strength was calculated at a height of three feet above ground.
- All line currents were assumed to be balanced (i.e., neutral or ground currents are not considered).
- No conductor shielding was considered.
- Terrain was assumed to be flat.
- Project dominant power flow directions were used.
- All calculations were based on preliminary engineering.

The calculated magnetic field value for UG1 at the north and south edges of the ROW is
approximately 0.1 milliGauss (mG), which is approximately 0.4% of the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route. While UG1 results in a significant reduction in magnetic field levels compared with the overhead design, the cost to underground the proposed transmission line in the Chino Hills area would not be “low-cost” as defined by the Commission’s EMF Policies.82

B. UG2: Underground Single-Circuit XLPE with Three Cables per Phase and Ducts & Vaults for Second Circuit, in Conduit in the Existing Chino Hills ROW

1. Description [P. Hlapcich]

UG2 is a single-circuit transmission line and consists of installing three XLPE cables per phase in duct bank in the existing ROW in the Chino Hills area. The infrastructure (i.e., duct banks, vaults, etc.) for UG2 is the same as the infrastructure for UG1. UG2 also requires construction of two transition stations, approximately 155’ by 235’ or nearly 1 acre in size, for the terminations structures, lightning arresters, switches, and possibly other equipment. An underground distribution line may be required to power equipment in the transition stations. Shunt compensation reactors located at one existing substation will be required.

In total, UG2 will require approximately 180,000 feet of 5000 kcmil XLPE cable for the single circuit, 144 cable pulling segments, 90 splice vaults, 135 splices, 18 terminations, 10 restraint vaults, 30,560 linear-feet of duct bank, 17,400 linear feet of HDD installation, and approximately 90,000 cubic yards of soil excavation. The key difference between UG2 and UG1 is that UG2 involves only constructing the infrastructure for the second circuit, but not installing the cable.

Cable Size and Configuration: Primary components of UG2 and the configuration of the duct banks are the same as those described for UG1 in Section VII.A.

Route Details: The route detail of UG2 is the same as the route detail for UG1 in Section VII.A.

82 As explained by the Commission in approving the Project, the “benchmark established for low-cost measures is 4% of the total budgeted project cost that results in an EMF reduction of at least 15% (as measures at the edge of the utility right-of-way).” D.09-12-044 at 66.
Installation of UG2: The construction and installation activities for UG2 are the same as those described for UG1 in Section VII.A.

Duct Bank Systems: UG2’s duct bank system is the same as that described for UG1 in Section VII.A.

Transition Stations: The transition station requirements, including layout, for UG2 are the same as those described for UG1 in Section VII.A, although initially there will be installed equipment for only a single circuit.

Cable Pulling: The description of cable pulling for UG2 is the same as that described in UG1. However, UG2 will require only half as much cable as UG1 due to cable being pulled for only one circuit. This results in the reduction from 288 pulling segments to 144 pulling segments.

Cable Accessories Installation: The installation of cable accessories is the same as that described for UG1 in Section VII.A.

Operation and Maintenance: The operation and maintenance requirement for UG2 is the same as that described for UG1 in Section VII.A.

Changes as a Result of Further Engineering: Major changes as a result of additional engineering are the same for UG2 as that described in UG1.

2. Engineering and Technical Feasibility [P. Hlapcich]

UG2 should be technically feasible. As discussed in Section II.D, this configuration provides the best operational capacity needed for the present load needs while allowing low impact cable installation when the cable for the second circuit is needed. Should SCE be ordered to implement UG2, disruptive trenching work and the final grading and landscaping will only need to be done once. Additional engineering and technical feasibility considerations are the same as those described in UG1.

3. Environmental Issues [J. Leung]

The environmental issues for UG2 are identical to UG1, described in Section VII.A.

4. Permanent Land Use Impacts [M. Quiroga]

The land use impacts for UG2 are identical to UG1, described in Section VII.A.
5. **Timing [C. Adamson]**

Under a best case scenario based on a number of optimistic assumptions, the timing for UG2 likely would place the first circuit in-service in January 2016, and the duct bank for the second circuit would be completed in 2017. This schedule is subject to change in the testimony to be submitted on February 28, 2013 after additional information is available. The schedule for UG2 is provided in Attachment DD.83

6. **Estimated Construction Costs [D. Heiss]**

The estimated total construction cost of UG2 amounts to $620 million, which is $448 million more than the $172 million estimated total cost of the Approved Route. This $620 million includes the cost to remove previously constructed structures, construct underground portions, complete the construction of the rest of Segment 8A, and the ITD costs that include $16 million of cost spent to date, which would be abandoned.84

7. **EMF Considerations [G. Sias]**

The calculated magnetic field value for UG2 at the north edge of the ROW is approximately 0.2 mG, which is approximately 0.7% of the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route.85 The calculated magnetic field value for UG2 at the south edge of the ROW is approximately 0.1 mG, which is approximately 0.4% of the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route. While UG2 results in a significant reduction in magnetic field levels compared with the overhead design, the cost to underground the proposed transmission line in the Chino Hills area would not be “low-cost” as defined by the Commission’s EMF Policies.

83 Attachment DD, Preliminary Underground Schedules at 3-4.
84 See supra Table 5, Estimated Costs.
85 See supra Section VII.A.7 for assumptions on calculated magnetic field values.
C. UG3: Underground Single-Circuit XLPE with Two Cables per Phase, with Ducts and Structures for a Third Cable and Second Circuit, in Conduit in the Existing Chino Hills ROW

1. Description [P. Hlapcich]

UG3 is a single-circuit transmission line and consists of installing two XLPE cables per phase in duct bank in the existing ROW in the Chino Hills area. The basic infrastructure (i.e., duct banks, vaults, etc.) for UG3 is the same as the infrastructure for UG1. UG3 also requires construction of two transition stations, approximately 155’ by 235’ or nearly 1 acre in size, for the terminations structures, lightning arresters, switches, and possibly other equipment. An underground distribution line may be required to power equipment in the transition stations. Shunt compensation reactors located at one existing substation will be required.

In total, UG3 will require 120,000 feet of 5000 kcmil XLPE cable, 96 cable pulling segments, 90 splice vaults, 90 splices, 12 terminations, 10 restraint vaults, 30,560 linear-feet of duct bank, 17,400 linear feet of HDD installation, and approximately 90,000 cubic yards of soil excavation.

Cable Size and Configuration: Primary components of UG3 and the configuration of the duct banks are the same as those described for UG1 in Section VII.A.

Route Details: The route detail of UG3 is the same as the route detail for UG1 in Section VII.A.

Installation of Option UG3: The construction and installation activities for UG3 are the same as those described for UG1 in Section VII.A.

Duct Bank Systems: UG3’s duct bank system is the same as that described for UG1 in Section VII.A.

Transition Stations: The transition station requirements, including layout, for UG3 are the same as those described for UG1 in Section VII.A, although initially there will be installed equipment for only a single circuit.

Cable Pulling: The description of cable pulling for UG3 is the same as that described for UG1 in Section VII.A. However, UG3 will only require 96 cable pulling segments as
opposed to UG1’s requirement for 288, as initially only two cables per phase will be pulled for a single circuit.

**Cable Accessories Installation:** The installation of cable accessories is the same as that described for UG1 in Section VII.A.

**Operation and Maintenance:** The operation and maintenance requirement for UG3 is the same as that described for UG1 in Section VII.A.

**Changes as a Result of Further Engineering:** Major changes as a result of additional engineering are the same for UG3 as those described for UG1 in Section VII.A.

2. **Engineering and Technical Feasibility [P. Hlapcich]**

UG3 should be technically feasible. As discussed in Section II.D, UG3’s two cables per phase provides the second-best option for meeting operational capacity for the present load needs. Also, UG3 allows for low impact cable installation to install the third cable in the first circuit or when the second circuit is needed. As a two cables per phase underground configuration, however, UG3 provides operational concerns if one of the two cables fails during operation. Additional engineering and technical feasibility considerations are the same as those described in UG1.

3. **Environmental Issues [J. Leung]**

The environmental issues for UG3 are identical to UG1, described in Section VII.A.

4. **Permanent Land Use Impacts [M. Quiroga]**

The land use impacts for UG3 are identical to UG1, described in Section VII.A.

5. **Timing [C. Adamson]**

Under a best case scenario based on a number of optimistic assumptions, the timing for UG3 would place the first circuit in-service in November 2015, and the duct bank for the second circuit would be completed in 2016. This schedule is subject to change in the testimony to be submitted on February 28, 2013 after additional information is available. The schedule for UG3 is provided in Attachment DD.86

86 Attachment DD, Preliminary Underground Schedules at 5-6.
6. Estimated Construction Costs [D. Heiss]

The estimated total construction cost of UG3 amounts to $566 million, which is $394 million more than the $172 million estimated total cost of the Approved Route. This $566 million includes the cost to remove previously constructed structures, construct underground portions, complete the construction of the rest of Segment 8A, and the ITD costs that include $16 million of cost spent to date, which would be abandoned.\(^87\)

7. EMF [G. Sias]

The calculated magnetic field value for UG3 at the north edge of the ROW is approximately 0.1 mG, which is approximately 0.4% of the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route.\(^88\) The calculated magnetic field value for UG3 at the south edge of the ROW is less than 0.1 mG, which is less than 0.4% of the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route. While UG3 results in a significant reduction in magnetic field levels compared with the overhead design, the cost to underground the proposed transmission line in the Chino Hills area would not be “low-cost” as defined by the Commission’s EMF Policies.

D. UG4: Underground Single-Circuit XLPE with Three Cables per Phase in Conduit in the Existing Chino Hills ROW (Functionally Equivalent to Option 10 in Supplemental ACR Response)

1. Description [P. Hlapcich]

UG4 is a single-circuit transmission line and consists of installing three XLPE cables per phase in duct bank in the existing ROW in the Chino Hills area. Unlike UG1, UG4 will only be constructed with one duct bank. UG4 also requires construction of two transition stations, approximately 155’ by 235’ or nearly 1 acre in size, for the terminations structures, lightning arresters, switches, and possibly other equipment. An underground distribution line may be required to power equipment in the transition stations. Shunt compensation reactors located at one existing substation will be required.

\(^87\) See supra Table 5, Estimated Costs.

\(^88\) See supra Section VII.A.7 for assumptions on calculated magnetic field values.
In total, UG4 will require 180,000 feet of 5000 kcmil XLPE cable, 144 cable pulling segments, 45 splice vaults, 135 splices, 18 terminations, 5 restraint vaults, 15,280 linear-feet of duct bank, 8,400 linear feet of HDD installation, and approximately 45,000 cubic yards of soil excavation.

**Cable Size and Configuration:** Primary components of UG4 and the configuration of the duct banks are the same as those described for UG1 in Section VII.A.

**Route Details:** The route detail of UG4 is the same as that described for UG1 in Section VII.A. However, in UG4, SCE will only install one duct bank in the northern portion of the ROW to leave room for an additional second circuit in the southern portion of the ROW.

**Installation of UG4:** The construction and installation activities for UG4 are the same as those for UG1 in Section VII.A.

**Duct Bank Systems:** UG4’s duct bank system is the same as that described for UG1. However, there will only be one duct bank for UG4.

**Transition Stations:** The transition station requirements, including layout, for UG4 are the same as those described for UG1 in Section VII.A, although SCE will install equipment for only a single circuit.

**Cable Pulling:** The description of cable pulling for UG4 is the same as that described for UG1 in Section VII.A. However, UG4 will only require 144 cable pulling segments as opposed to UG1’s requirement for 288, because only three cables per phase will be pulled for a single-circuit.

**Cable Accessories Installation:** The installation of cable accessories is the same as that described for UG1 in Section VII.A.

**Operation and Maintenance:** The operation and maintenance requirement for Option UG4 is the same as that described for UG1 in Section VII.A.

**Changes as a Result of Further Engineering:** Major changes as a result of additional engineering are the same for UG4 as those described for UG1 in Section VII.A.

2. **Engineering and Technical Feasibility [P. Hlapcich]**

UG4 should be technically feasible. UG4 provides an option for meeting operational
capacity for the present load need only. Unlike UG3, however, UG4 does not allow low impact installation of a future second circuit because SCE will have to grade, trench and install the cable for the second circuit at a later date. That is, any final grading, restoration, and/or landscaping completed after installation of the first circuit would have to be torn-up and redone when the ducts and structures for the second circuit are installed. Additional engineering and technical feasibility considerations are the same as those described in UG1.

3. **Environmental Issues [J. Leung]**

The environmental issues for UG4 are identical to UG1, described in Section VII.A. If a second circuit is subsequently installed, additional environmental impacts may occur.

4. **Permanent Land Use Impacts [M. Quiroga]**

The land use issues for UG4 are identical to UG1, described in Section VII.A.

5. **Timing [C. Adamson]**

Under a best case scenario based on a number of optimistic assumptions, the timing for UG4 likely would place the first circuit in-service in January 2016. This schedule is subject to change in the testimony to be submitted on February 28, 2013 after additional information is available. The schedule for UG4 is provided in Attachment DD.\(^{89}\)

6. **Estimated Construction Costs [D. Heiss]**

The estimated total construction cost of UG4 amounts to $540 million, which is $368 million more than the $172 million estimated total cost of the Approved Route. This $540 million includes the cost to remove previously constructed structures, construct underground portions, complete the construction of the rest of Segment 8A, and the ITD costs that include $16 million of cost spent to date on the Approved Route, which would be abandoned.\(^{90}\)

7. **EMF Considerations [G. Sias]**

The calculated magnetic field value for UG4 at the north edge of the ROW is approximately 0.2 mG, which is approximately 0.7% of the calculated value of 27.0 mG.

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\(^{89}\) Attachment DD, Preliminary Underground Schedules at 7-8.

\(^{90}\) *See supra* Table 5, Estimated Costs.
presented in the 2007 FMP for the Approved Route.\textsuperscript{91} The calculated magnetic field value for
UG4 at the south edge of the ROW is approximately 0.1 mG, which is approximately 0.4% of
the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route. While this
underground configuration results in a significant reduction in magnetic field levels compared
with the overhead design, the cost to underground the proposed transmission line in the Chino
Hills area would not be “low-cost” as defined by the Commission’s EMF Policies.

E. UG5: Underground Single-Circuit XLPE with Two Cables per Phase
in Conduit in the Existing Chino Hills ROW (Functionally Equivalent
to Option 11 in Supplemental ACR Response)

1. Description [P. Hlapcich]

UG5 is a single-circuit transmission line and consists of installing two XLPE cables per
phase in duct bank in the existing ROW in the Chino Hills area. Unlike UG1, UG5 will only be
constructed with one duct bank, which will contain infrastructure for three cables per phase.
UG5 also requires construction of two transition stations, approximately 155’ by 235’ or nearly 1
acre in size, for the terminations structures, lightning arresters, switches, and possibly other
equipment. An underground distribution line may be required to power equipment in the
transition stations. Shunt compensation reactors located at one existing substation will be
required.

In total, UG5 will require 120,000 feet of 5000 kcmil XLPE cable, 96 cable pulling
segments, 45 splice vaults, 90 splices, 12 terminations, 5 restraint vaults, 15,280 linear-feet of
duct bank, 8,400 linear feet of HDD installation, and approximately 45,000 cubic yards of soil
excavation.

Cable Size and Configuration: Primary components of UG5 and the configuration of
the duct banks are the same as those described for UG1 in Section VII.A.

Route Details: The route detail of UG5 is the same as that for UG4.

Installation of Option UG5: The construction and installation activities for UG5 are the
same as those described for UG1 in Section VII.A.

\textsuperscript{91} See supra Section VII.A.7 for assumptions on calculated magnetic field values.
Duct Bank Systems: UG5’s duct bank systems are the same as those described for UG4.

Transition Stations: The transition station requirements, including layout, for UG5 are the same as those described for UG1 in Section VII.A, although there will be installed equipment for only a single circuit.

Cable Pulling: The description of cable pulling for UG5 is the same as that described in UG3.

Cable Accessories Installation: The installation of cable accessories is the same as that described for UG1 in Section VII.A.

Operation and Maintenance: The operation and maintenance requirement for UG5 is the same as that described for UG1 in Section VII.A.

Changes as a Result of Further Engineering: Major changes as a result of additional engineering are the same for UG5 as those described for UG1 in Section VII.A.

2. Engineering and Technical Feasibility [P. Hlapcich]

UG5 should be technically feasible. As discussed in Section II.D, UG5 provides an option for meeting operational capacity for the present load needs. Unlike UG3, however, UG5 does not allow low impact installation of a future second circuit because SCE will have to grade, trench and install the cable for the second circuit at a later date. That is, any final grading, restoration, and/or landscaping completed after installation of the first circuit would have to be torn-up and redone when the ducts and structures for the second circuit are installed.

Due to the two cables per phase construction, UG5 also implicates operational concerns if one of the two cables fails during operation. UG5 is therefore not a technically desirable option. Additional engineering and technical feasibility considerations are the same as those described in UG1.

3. Environmental Issues [J. Leung]

The environmental issues for UG5 are identical to UG1, described in Section VII.A. If a second circuit is subsequently installed, additional environmental impacts may occur.

4. Permanent Land Use Impacts [M. Quiroga]

The land use issues for UG5 are identical to UG1, described in Section VII.A.
5. **Timing [C. Adamson]**

Under a best case scenario based on a number of optimistic assumptions, the timing for UG5 would place the first circuit in-service in November 2015. This schedule is subject to change in the testimony to be submitted on February 28, 2013 after additional information is available. The schedule for UG5 is provided in Attachment DD.92

6. **Estimated Construction Costs [D. Heiss]**

The estimated total construction cost of UG5 amounts to $486 million, which is $314 million more than the $172 million estimated total cost of the Approved Route. This $486 million includes the cost to remove previously constructed structures, construct underground portions, complete the construction of the rest of Segment 8A, and the ITD costs that include $16 million of cost spent to date on the Approved Route, which would be abandoned.93

7. **EMF [G. Sias]**

The calculated magnetic field value for UG5 at the north edge of the ROW is approximately 0.1 mG, which is approximately 0.4% of the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route.94 The calculated magnetic field value for UG5 at the south edge of the ROW is less than 0.1 mG, which is less than 0.4% of the calculated value of 27.0 mG presented in the 2007 FMP for the Approved Route. While UG5 results in a significant reduction in magnetic field levels compared with the overhead design, the cost to underground the proposed transmission line in the Chino Hills area would not be “low-cost” as defined by the Commission’s EMF Policies.

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92 Attachment DD, Preliminary Underground Schedules at 9-10.
93 See supra Table 5, Estimated Costs.
94 See supra Section VII.A.7 for assumptions on calculated magnetic field values.
Appendix A
Witness Qualifications
SOUTHERN CALIFORNIA EDISON COMPANY

QUALIFICATIONS AND PREPARED TESTIMONY OF CHARLES ADAMSON

Q. Please state your name and business address for the record.
A. My name is Charles Adamson, and my business address is 6 Pointe Drive, Brea, California 92821.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I am a Manager of Large Transmission Projects in the Transmission and Distribution Business Unit at SCE. I am also currently the acting Project Manager of licensing for the Tehachapi Renewable Transmission Project (TRTP) Segments 4-11. As Project Manager, I have been responsible for all licensing aspects of the TRTP including siting, preliminary engineering, cost, schedule, and environmental analysis.

Q. Briefly describe your educational and professional background.
A. I received a Certificate in Project Management from the University of California Irvine in 2000. My experience includes project management, engineering, technical training, and technical support. From 1990 to 1997 my responsibilities included technical training and support, as well as engineering, design, and process improvement. From 1997 to 2001, I managed substation automation and generation divestiture projects. From 2001 to 2006, I managed both licensing and construction of transmission and substation projects. From 2006 to 2010, I managed the licensing of large transmission projects. From 2010 to present I manage both the licensing and construction of large transmission and substation projects.

Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.
Q. Was this material prepared by you or under your supervision?
A. Yes, it was.
Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.
Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?
A. Yes, it does.
Q. Does this conclude your qualifications and prepared testimony?
A. Yes, it does.
QUALIFICATIONS AND PREPARED TESTIMONY OF JORGE CHACON

Q. Please state your name and business address for the record.
A. My name is Jorge Chacon and my business address is 3 Innovation Way, Pomona, Walnut Grove Avenue, Rosemead, California 91768.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I am the manager of the Generation Interconnection Planning Group in SCE’s Transmission and Distribution Business Unit. In that capacity, I am responsible for, among other things, managing the planning of high voltage transmission systems for SCE, including the Tehachapi Renewable Transmission Project (TRTP).

Q. Briefly describe your educational and professional background.
A. I obtained my Bachelor of Science degree in Electrical Engineering, from California State Polytechnic University, Pomona, in 1997. I am presently pursuing a Master in Business Administration from the University of La Verne. Over the past fourteen years, I have performed transmission planning studies regarding transmission capability in the Tehachapi area to accommodate new generation.

Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?
A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best
Q. Does this conclude your qualifications and prepared testimony?
A. Yes, it does.
SOUTHERN CALIFORNIA EDISON COMPANY QUALIFICATIONS AND
PREPARED TESTIMONY OF DEAN HEISS

Q. Please state your name and business address for the record.
A. My name is Dean Heiss, and my business address is 6 Pointe Drive, Brea, California 92821.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I am a Manager assigned to develop and implement assigned Project Controls initiatives supporting SCE’s Major Project Organization.

Q. Briefly describe your educational and professional background.
A. I received my undergraduate degree in Aeronautical Science from Embry-Riddle Aeronautical University in 2003, earned my Project Management Certificate from California Institute of Technology in 2011, and my Lean Six Sigma Green Belt certification from IIE/University of Southern California was achieved in 2012. I joined SCE in 2009 as a Project Cost Engineer for the Tehachapi Renewable Transmission Project (TRTP). Prior to assuming this position, I worked as a Project Controls consultant with SCE - Real Properties and with Pfizer.

Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?
A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best
Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.
SOUTHERN CALIFORNIA EDISON COMPANY QUALIFICATIONS AND
PREPARED TESTIMONY OF PETER L. HLPACICH

Q. Please state your name and business address for the record.
A. My name is Peter L. Hlapcich, and my business address is 2244 Walnut Grove Avenue, Rosemead, California 91770.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I am the Manager of SCE’s Transmission Group and the Civil/Structural/Geotechnical Group, and work with both the overhead and underground groups.

Q. Briefly describe your educational and professional background.
A. I received a BS in Civil Engineering from California State University at Long Beach in 1971, a MS in Civil Engineering from California State University at Long Beach in 1976, and a MS in Organization Development from Pepperdine University in 1998. I am a Registered Civil Engineer in the State of California. I have worked for Southern California Edison for 41 years. I have been an engineer in and have managed various engineering groups within SCE including: Apparatus (major utility equipment), Substation (engineering of substation additions), Transmission (engineering of transmission facilities both overhead and underground), Civil (grading and other facility designs), Structural (substation and transmission structures), and Geotechnical (soils engineering).

Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?
A. Yes, it was.
Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?
A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?
A. Yes, it does.
SOUTHERN CALIFORNIA EDISON COMPANY QUALIFICATIONS AND
PREPARED TESTIMONY OF JENNIFER LEUNG

Q. Please state your name and business address for the record.
A. My name is Jennifer Leung, and my business address is 2244 Walnut Grove Avenue, Rosemead, California 91770.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I am a biologist in SCE’s Corporate Environmental Services. I am responsible for environmental compliance and permitting associated with biological resource management.

Q. Briefly describe your educational and professional background.
A. I obtained a Bachelor of Science degree in Applied Ecology from the University of California, Irvine in 2000. Over the past twelve years, I have been involved in transportation and utility project permitting, compliance and mitigation responsibilities.

Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?
A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?
A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?
A. Yes, it does.
Q. Please state your name and business address for the record.
A. My name is Steve Peters, and my business address is 2244 Walnut Grove Ave.,
    Rosemead, CA 91770.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I am Manager of Financial Analysis in the Corporate Financial Planning Group within
    the Treasurer’s Department. As Manager of Financial Analysis, I have been responsible
    for financial review of large capital projects, corporate capital governance, and credit,
    cash and liquidity forecasting.

Q. Briefly describe your educational and professional background.
A. I graduated from the University of Utah with a Bachelor of Science Degree in Finance
    and a Bachelor of Science Degree in Business Management. I also earned a Masters in
    Business Administration from California State University, Long Beach. I have more than
    20 years of experience in financial analysis, budget development and reporting, cost
    management, financial forecasting, and audits. I have held management positions at
    SCE, Edison International, and Edison Enterprises.

Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of *Southern
    California Edison Company’s Preliminary Underground Testimony in Response to the
    Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable
    Transmission Project (TRTP)*, as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?
A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.
Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?
A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?
A. Yes, it does.
SOUTHERN CALIFORNIA EDISON COMPANY
QUALIFICATIONS AND PREPARED TESTIMONY OF MONICA QUIROGA

Q. Please state your name and business address for the record.
A. My name is Monica Quiroga, and my business address is 6 Pointe Drive, Brea, California 92821.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I am a Project Manager of Real Properties within SCE’s Transmission and Distribution Unit. I am also currently the Project Manager of acquisition for Tehachapi Renewable Transmission Project (TRTP) Segments 4-11. As Project Manager, I assume responsibility for acquiring land and land rights of a project once it has been approved by SCE’s management.

Q. Briefly describe your educational and professional background.
A. I received Bachelor’s Degrees in Political Science and Spanish from California State University, Fullerton in May 2000. In January 2002, I received a Master’s Degree in International Administration from the University of Miami, Coral Gables. In 2009, I received a certificate in Project Management from the University of California, Irvine. I am currently pursuing a Masters in Leadership and Management from the University of La Verne and expect to complete this degree by December 2012.

Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?
A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.
Q. Please state your name and business address for the record.
A. My name is John Rector, and my business address is 11401 Lamar Avenue, Overland Park, Kansas 66211.

Q. Briefly describe your present relationship with Southern California Edison Company (SCE).
A. I have been retained by SCE as a consultant to address issues raised by the potential undergrounding of a portion of Segment 8A of the Tehachapi Renewable Transmission Project (TRTP) that crosses through the City of Chino Hills.

Q. By whom are you employed?
A. I am employed by Black & Veatch Corporation (Black & Veatch).

Q. Briefly describe your present responsibilities at Black & Veatch.
A. I am an Associate Vice President and a Senior Project Manager. My responsibilities include managing the engineering, procurement, and construction of overhead and underground transmission line and substation projects, as well as management and oversight for the development of design specifications, drawings, and cost estimations for those projects.

Q. Briefly describe your educational and professional background.
A. I obtained a Bachelor of Science in Electrical Engineering from Kansas State University in 1976. I joined Black & Veatch in 1977. Before becoming an Associate Vice President and Senior Project Manager, I previously served as Section Leader of the Overhead and Underground Transmission Line Design Group for the Power Delivery business line, and before that served as Project Engineer responsible for detailed design of overhead and underground transmission lines. Throughout my career, I have prepared class materials and taught overhead and underground transmission line design engineering courses at Black & Veatch and at client’s offices. My design and construction experience includes projects from 46 kV to 500 kV, and I also have managed 765 kV structure design projects.
I also served for eighteen months as a resident engineer from 1985 to 1987 at the Stanton Energy Center in Orlando, Florida, where my responsibilities included the construction inspection of the electrical construction of the underground duct bank and cable system, coal yard facilities, and portions of the overhead transmission line. I am a voting member of the Insulated Conductors Committee of the IEEE, and have co-authored Chapter 13 of the Revised EPRI Green Book, specifically addressing construction of underground transmission facilities. I am a registered professional engineer in Texas, Vermont, Maryland, Kansas, and Michigan.

Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.
QUALIFICATIONS AND PREPARED TESTIMONY OF FOREST RONG

Q. Please state your name and business address for the record.
A. My name is Forest Rong, and my business address is 11401 Lamar Avenue, Overland Park, Kansas 66211.

Q. Briefly describe your present relationship with Southern California Edison Company (SCE).
A. I have been retained by SCE as a consultant to address issues raised by the potential undergrounding of a portion of Segment 8A of the Tehachapi Renewable Transmission Project (TRTP) that crosses through the City of Chino Hills.

Q. By whom are you employed?
A. I am employed by Black & Veatch Corporation (Black & Veatch).

Q. Briefly describe your present responsibilities at Black & Veatch.
A. I am an Engineering Manager and the Section Head of the underground transmission group in the Energy Division’s Power Delivery Business. My responsibilities include the supervision and management of underground and underwater transmission line projects using various high voltage cable technologies.

Q. Briefly describe your educational and professional background.
A. I obtained a Bachelor of Engineering in Electrical Insulation and Cables from Harbin Institute of Electrical Technology in 1995, and a Master of Engineering in Electrical Engineering from McMaster University in 2001. Before joining Black & Veatch, I had two years of research and teaching experience at McMaster University and three years of engineering experience at ABB China Ltd. and China National Electric Wire & Cable Imp/Exp Corporation. I joined Black & Veatch in 2001. My experience covers system planning and studies, conceptual and detail engineering design, project cost estimates and specification development, and project coordination and management on underground and underwater transmission projects domestically and internationally. I am a registered professional engineer in California and Ohio, as well as Alberta, British Columbia, and
Q. What is the purpose of your testimony in this proceeding?

A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?

A. Yes, it does.
Q. Please state your name and business address for the record.
A. My name is Glenn G. Sias, and my business address is 1218 South 5th Avenue, Monrovia, California 91016.

Q. By whom are you employed?
A. I am employed by Southern California Edison Company (SCE).

Q. Briefly describe your present responsibilities at SCE.
A. I work as the Manager of SCE’s Electric and Magnetic Fields (EMF) and Energy Group in the Corporate Health and Safety Department. As the EMF and Energy Group Manager, I oversee SCE’s activities related to EMF, including the preparation of studies on EMF reduction techniques for new electrical facilities, responding to customer and employee EMF inquiries, and supporting EMF research projects. I also oversee the preparation of Field Management Plans for SCE’s transmission and substation projects.

Q. Briefly describe your educational and professional background.
A. I received a Bachelor of Science Degree in electrical engineering from University of California, Los Angeles (UCLA) and my Master of Science degree in Environmental Health Sciences from UCLA’s School of Public Health. I am currently pursuing my doctorate in Environmental Science and Engineering at UCLA. I began my career at SCE in its EMF research group from 1991 to 1993. I continued my employment at SCE as an EMF technical specialist from 1993 until I moved to my current position in 2007. My experience with magnetic fields created by electrical facilities includes developing the first version of FIELDS, SCE’s 2-D magnetic field modeling software, characterizing fields created by power lines and substations using computer models and measurements, conducting well over a thousand customer magnetic field surveys including many at homes near transmission lines, and preparation of field management plans (FMPs) for SCE’s projects. I participated in the 2006 workshop to develop the current California EMF Design Guidelines for Electrical Facilities.
Q. What is the purpose of your testimony in this proceeding?
A. The purpose of my testimony in this proceeding is to sponsor portions of Southern California Edison Company’s Preliminary Underground Testimony in Response to the Assigned Commissioner’s Scoping Memo and Ruling on the Tehachapi Renewable Transmission Project (TRTP), as identified in the Table of Contents thereto.

Q. Was this material prepared by you or under your supervision?
A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?
A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?
A. Yes, it does.

Q. Does this conclude your qualifications and prepared testimony?
A. Yes, it does.