DRAFT STUDY PLAN
for the
Joint Performance of the
2020 California-wide Transmission Plan

July 22, 2009

Developed by the
Technical Steering Committee

I. OBJECTIVES

The objectives of this study are:

1. To develop a California state-wide transmission plan to meet the state's 33% RPS renewable goal using the RETI Phase 2A conceptual plan as a starting point.

2. To ensure coordination with all members' individual transmission plans.

II. ASSUMPTIONS

The following three base cases will be developed and studied:

- Case A: 2020 Northern California adverse weather (90/10) case[1]
- Case B: 2020 Southern California adverse weather (90/10) case[2]
- Case C: 2020 Normal Weather (50-50) case

Each California utility will provide expected 50/50 and 90/10 annual peak load forecasts, disaggregated across the individual load buses with the utility's distribution service area, with applicable energy efficiency and demand response assumptions embedded in the forecast.

Table 1 shows existing path ratings. When the applicable base cases have been developed, the unpopulated columns in Table 1 will be filled in with the simulated all-lines-in-service power flows across the identified paths for the indicated cases.

[1] Northern California loads will be set at forecast 1-in-10 year load levels for year 2020. All other WECC loads will be based on the load levels reflected in the starting point WECC powerflow case, adjusted for expected load growth to the year 2020.

[2] Southern California loads will be set at forecast 1-in-10 year load levels for year 2020. All other WECC loads will be based on the load levels reflected in the starting point WECC powerflow case, adjusted for expected load growth to the year 2020.

Table 1

			Northern California Adverse Summer Weather		Southern California Adverse Summer Weather		Normal Summer Weather	
Path	Transfer Path	Path Rating (MW)	Case A0 (WECC case) (MW)	Case A1 (WECC Case w/ RETI upgrades and WECC renewables) (MW)	Case B0 (WECC Case) (MW)	Case B1 (WECC Case w/ RETI upgrades and WECC renewables) (MW)	Case C0 (WECC case) (MW)	Case C1 (WECC Cas w/ RETI upgrades an WECC renewables (MW)
66	California Oregon Intertie (COI)	4800						
65	Pacific DC Intertie (PDCI)	3100						
49	East-of-the-River (EOR)	9300						
46	West-of-the-River (WOR)	10623						
26	Midway-Vincent	4000 (N-S), 3000 (S-N)						
27	Intermountain DC (IPP DC)	2400						
15	Midway-Los Banos	3265 (N-S), 5400 (S-N)						

Load and Resource (L&R) tables for each case will be assembled and appended to the study report as an Appendix. Resource additions will include (a) renewable resources located within the Competitive Renewable Energy Zones (CREZs) and out of state regions within the RETI footprint that are contained in the RETI Phase 2A report, and (b) renewable resources located outside the RETI footprint that are identified in the Western Renewable Energy Zone (WREZ) – Phase 1 Report. The additions will be sufficient to achieve California's 33% renewable goal as well as the established renewable goals of the other WECC regions.

N-1 List
For Power Flow Runs Only

N-1 Contingencies[3]
PDCI bipole outage
[All 230 kV, 287 kV, and 500 kV lines in California]
[Selected major external 230, 345, and 500 kV lines]
[Selected major lower voltage lines in California]

G-1 Contingencies
[All generators exceeding 500 MW in California]
[Selected external generators exceeding 500 MW]

N-2 List
For Power Flow Runs Only

N-2 Contingencies
Malin - Round Mt. #1 and #2 500kV
Round Mt. - Table Mt. #1 and #2 500 kV
Table Mt. – Tesla and Table Mt.- Vaca 500 kV
Table Mt. – Tesla and Vaca – Tesla 500 kV
Tesla – Los Banos and Tesla – Tracy 500 kV
Tesla – Los Banos and Tracy – Los Banos 500 kV
Diablo – Midway #1 and #2 500 kV
Los Banos - Gates #1 and Los Banos – Midway #2 500 kV
Los Banos – Midway #2 and Gates – Midway #1 500 kV
IPP DC 500 kV Bipole
Midway - Vincent #1 and #2 500 kV
Palo Verde - Westwing #1 and #2 500 kV
McCullough – Victorville #1 and #2 500 kV
Lugo – Mira Loma #2 and #3 500 kV
Lugo – Mohave and Lugo – Eldorado 500 kV
Lugo – Vincent #1 and #2 500 kV
Adelanto-Rinaldi 500 kV and Victorville-Rinaldi 500 kV
Adelanto-Victorville #1 and #2 500 kV
Victorville-Century #1 and 2 287 kV

G-2 Contingencies
SONGS 2&3
Diablo Canyon 1&2
Palo Verde 2&3

[3] Including all transmission line segments added as part of the RETI upgrades.

III. STUDY GUIDELINES AND CRITERIA

1. General

The criteria contained within this document are intended to provide a framework from which computer simulation studies will be performed to model future system conditions and evaluate the system performance.

The General Electric Power System Planning Program (GE-PSLF) will be used in conjunction with in-house Engineer Programming Control Language (EPCL) routines to help analyze the study results. Analysis using GE-PSLF may be augmented with other powerflow applications, including the Powertech Voltage Stability Analysis Tool (VSAT).

In general, the criteria applied will be based on the following procedures and criteria currently in use:

1. WECC "Reliability Criteria For Transmission System Planning"

2. WECC "Procedures for Regional Planning Project Review and Rating Transmission Facilities"

3. Cal-ISO Grid Planning Criteria

4. WECC "Voltage Stability Criteria, Undervoltage Load Shedding Strategy, and Reactive Power Reserve Monitoring Methodology"; and

5. NERC Reliability Standards TPL-001, TPL-002, TPL-003

6. Each member's Specific Local Planning Criteria

2. System Representation

All system studies will be performed using the latest available data for the WECC interconnected system for the 2020 time frame being studied. A WECC full-loop representation will be used; this includes the Western United States, Western Canada and the system of Comisión Federal de Electricidad (CFE) of Baja California, Mexico.

3. Methodology to Incorporate the RETI Conceptual Transmission Plan

To the extent not already included in the WECC base case, the network upgrades identified in the RETI Phase 2A process (including new substations as well as expansion of existing substations in order to accommodate renewable generation from the CREZs included in the RETI Phase 2A final report) will be added to the WECC-full loop representation described above. These additions will be reflected in Case A1, Case B1 and Case C1 (refer to Table 1).

4. Power Flow Guidelines

Power flow studies will be performed utilizing the following guidelines:

WECC Generation Dispatch Assumptions

For performance of the peak load power flow cases, the following simultaneous generator output assumptions will be made:

- Wind: 20% of nameplate capacity
- Solar: 100% of nameplate capacity
- Geothermal: 100% of nameplate capacity
- Biomass: 100% of nameplate capacity
- Existing gas-fired generation: Dispatchable gas-fired generation throughout the WECC should be shut-down/curtailed in an economically rational manner as needed to balance load and generation.
- All Northern California hydro systems north of Midway will be dispatched within existing nomogram limits considering historical dispatch patterns for average hydro year
- Historical hydro dispatch for remaining hydro generation for average hydro year

Thermal Capacity Limits

No transmission element will be loaded above 100% of its continuous rating under base case (all facilities in service) conditions. For loss of the next system element(s), no transmission system element will be loaded above its time-duration emergency rating after the application of applicable remedial action schemes (RAS).

See Table 2 for a description of the contingency analysis and criteria, including the test for adequate reactive margin.

Table 2

Power Flow Contingency Analysis	**Transient Stability Analysis** (Three-phase Fault at / Outage)	**Reactive Margin Adequacy**	**Voltage Stability Analysis**
• All 500 and 230 kV lines in California • Selected external major transmission lines • Selected N-2 contingencies with RAS • See list below.	• Selected major N-1 and N-2 contingencies • WECC criteria	• Selected major WECC transfer paths WECC reactive margin criteria (5% for N-1, 2.5% for N-2 in accordance with WECC Criteria TPL-(001 thru -003 WECC-1-CR[4], Requirements WRS3 and related Sub-Requirements WRS3.1, WRS3.2, WRS3.3 and WRS3.4)	• All 230 kV and 500 kV buses • WECC voltage stability criteria (5% for N-1[*], 10% for N-2) • 7% N-1 voltage drop permitted for SCE buses

Comment [CT1]: Is there a reference for this '*'?

[4] http://www.wecc.biz/Standards/WECC%20Criteria/TPL%20–%20(001%20thru%20004)%20–%20WECC%20–%201%20–%20CR%20-%20System%20Performance%20Criteria.pdf

N-1 List
For Power Flow, Reactive margin, and Post-Transient Voltage Stability Runs Only
(note that this list is a guideline and is not necessarily complete)

N-1 Contingencies[5]
PDCI bipole outage
[All 230 kV, 287 kV, and 500 kV lines in California]
[Selected major external 230, 345, and 500 kV lines]
[Selected major lower voltage lines in California]

G-1 Contingencies
[All generators exceeding 500 MW in California]
[Selected external generators exceeding 500 MW]

N-2 List
For Power Flow, Reactive margin, and Post-Transient Voltage Stability Runs Only
(note that this list is a guideline and is not necessarily complete)

N-2 Contingencies
Malin - Round Mt. #1 and #2 500kV
Round Mt. - Table Mt. #1 and #2 500 kV
Table Mt. – Tesla and Table Mt.- Vaca 500 kV
Table Mt. – Tesla and Vaca – Tesla 500 kV
Tesla – Los Banos and Tesla – Tracy 500 kV
Tesla – Los Banos and Tracy – Los Banos 500 kV
Diablo – Midway #1 and #2 500 kV
Los Banos - Gates #1 and Los Banos – Midway #2 500 kV
Los Banos – Midway #2 and Gates – Midway #1 500 kV
IPP DC 500 kV Bipole
Midway - Vincent #1 and #2 500 kV
Palo Verde - Westwing #1 and #2 500 kV
McCullough – Victorville #1 and #2 500 kV
Lugo – Mira Loma #2 and #3 500 kV
Lugo – Mohave and Lugo – Eldorado 500 kV
Lugo – Vincent #1 and #2 500 kV
Adelanto-Rinaldi 500 kV and Victorville-Rinaldi 500 kV
Adelanto-Victorville #1 and #2 500 kV
Victorville-Century #1 and 2 287 kV

G-2 Contingencies

[5] Including all transmission line segments added as part of the RETI upgrades.

SONGS 2&3
Diablo Canyon 1&2
Palo Verde 2&3

Contingency List For Transient Stability Runs Only
(note that this list is a guideline and is not necessarily complete)

[To Be Determined]

Table 3

Bus	Pre-Outage Min. Volt (p.u.)	Post-Disturbance Min. Volt (p.u.)	Remarks
Adelanto 500 kV	Flag if < 1.025	0.95	
Devers 500 kV	Flag if < 0.987	0.945	
Valley 500 kV	Flag if < 0.987	0.945	
SCE 500 kV	Flag if < 0.9975	0.966	*[Doesn't allow 5% drop]*
Sylmar 230 kV	Flag if < 0.99	0.95	
LADWP	1.00	0.95	
SDG&E 500 kV	Flag if < 0.94	0.90	
SDG&E 230 kV	Flag if < 0.98	0.97	
SCE 230 kV	Flag if < 0.95	0.90	
Devers 230 kV	Flag if < 0.95	0.90	
Mirage 230 kV	0.90	0.90	*[Doesn't allow 5% drop]*
Blythe 161 kV	Flag if < 0.95	0.91	
MWD	Flag if < 0.9875	0.95	

5. Stability Study Guidelines

Stability studies will be performed to establish stability transfer limits and to ensure system stability following a critical fault on the system. These studies will facilitate the development of the dynamic voltage support requirements, if required.

Machine Representation

- For the stability analysis, resources consistent with the time period studied will be dispatched to meet the load requirements in the base cases.
- Representation of turbine generators will be consistent with available turbine generator data.
- The base case power system stabilizers that are normally in-service within the WECC system will be modeled for the Heavy Summer operating period studied.
- For new generator technologies that do not yet have specific representations, the study group will make reasonable assumptions and choose the closest existing generator representation.
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Load Representation

- Induction Motors will be modeled at 20% of the total load across the WECC Region

System Disturbances

- System disturbances for stability studies will be initiated by a three-phase fault on the EHV bus adjacent to the major interconnection point and/or power plant of interest.

Fault Clearing Time

- Faults on the transmission lines being evaluated will be cleared in accordance with guidelines provided by the appropriate operating agents.

Underfrequency Load-Shedding Simulated

- The frequency will be monitored at key buses. If any stability run causes the frequency to drop sufficiently such that relays will "pick up", the underfrequency load-shedding data will be reviewed and updated as necessary.

Series Capacitors

- Series capacitor modeling during transient conditions is indicated by the attached switching sequences.

Unit Tripping

- Unit tripping of other utility generation and pumping loads on under-frequency will be modeled in accordance with WECC guidelines or those provided by the appropriate operating agent.

Generator Voltage Ride Through

- WECC regional standard.

Evidence of System Stability

The system will be considered stable if the following conditions are met:

- Machine Synchronism
    - All machines in the WECC interconnected system must remain in synchronism as demonstrated by relative rotor angles (unless modeling problems are identified and concurrence is reached that a problem does not really exist).
- Simulation Time and System Damping
    - A stability simulation will be deemed to exhibit positive damping if a line defined by the peaks of the machine relative rotor angle swing curves tends to intersect a second line connecting the valleys of the curves with the passing of time.
    - Corresponding lines on bus voltage swing curves will likewise tend to intersect. A stability simulation which satisfies these conditions will be defined as stable.
    - Duration of a stability simulation run will be ten seconds unless a longer time is required to ascertain stability.

- The analysis will start after the typically "noisy" transient period of up to about one second after the fault and associated system switching and remedial actions, and conclude at the end of the simulation.
- A case will be defined as marginally stable if it appears to have zero percent damping and the voltage dips are within (or at) the WECC Reliability Criteria limits.

6. Post-Transient Voltage Stability Study Guidelines

Post-transient studies will be performed to ensure the WECC Voltage Stability Criteria is met following credible outages within the system. Certain contingencies may activate RAS/SPS which will be included in the switching sequences as appropriate. See Table 2 for a list of the contingencies to be analyzed and criteria.

A. Study Assumptions:

- All loads will be modeled as constant MVA during the first few minutes following an outage or disturbance.
- All voltages at distribution substations will be restored to normal values by the transformer tap changers and other voltage control devices.
- Generator MVAR limits will be modeled as a single value for each generator since the reactive power capability curve will not be modeled in the program output.
- No manual operator intervention is allowed to increase the generator MVAR flow.
- Remedial actions such as generator dropping, load shedding and blocking of automatic generation control (AGC) will not be considered for single contingencies.
- Shunt capacitors (132 MVAR) at Adelanto and Marketplace will be used if the post-transient voltage deviation exceeds 5% at those buses. Although modeled as shunt capacitors the actual devices are automatically controlled SVCs.
- Shunt capacitors in the SCE service area will be modeled according to the SCE Centralized Grid Capacitor Control to be provided by SCE.
- All automatic switching will be allowed if the switching action can be completed within 3 minutes after the disturbance.
- Other assumptions:
  - Area Interchange: Disabled

- Governor Blocking: Base load flag will be used per WECC practice
- DC Line Transformer Tap Automatic Adjustment: Enabled
- Generator Voltage Control set to local except for Palo Verde, and selected Northwest generation
- Phase Shifter Control: Disabled
- Switched Shunt Devices: Disabled

B. Study Criteria:

The post-transient voltage deviations shall meet the WECC/NERC Planning Standards except for SCE area which allows 7% voltage drop for N-1 contingencies.

IV. STUDY METHODOLOGY

The methodology by which the studies will be performed is outlined as follows:

1. Development of Base Cases
   a. 2020 Heavy Summer Base Case (derived from the WECC 2019 HS case)
   b. Adjustment of system loads
   c. Agreement on major project assumptions
   d. Application of RETI-identified projects
   e. Development of contingency lists
   f. Agreement on system criteria

2. Sensitivities
   a. To the "North" cases: COI/PDCI at 4800/3100 MW (nomogram point)
   b. To the "North" cases: Path 15 5400 MW (South to North)
   c. A case simulating light load Winter Conditions: Starting from WECC Base Case WECC 2016-17HW1A, revise to simulate system conditions expected around 1700 - 1900 hour midweek in January for year 2020, with Northern California Load at approximately 60% of 2020 summer peak load.
      - Wind: 100% of nameplate
      - Solar: 0% of nameplate capacity
      - Geothermal: 100% of nameplate capacity
      - Biomass: 100% of nameplate capacity
      - Existing gas-fired generation: Dispatchable gas-fired generation throughout the WECC should be shut-down/curtailed in an economically rational manner as needed to balance load and generation.
      - All Northern California hydro systems north of Midway will be dispatched within existing nomogram limits considering historical dispatch patterns for average hydro year
      - Historical hydro dispatch for remaining hydro generation for average hydro year

3. Analysis
    a. Base-Case contingency analysis for thermal and voltage stability.
    b. Renewable generation is ramped up, displacing fossil generation
        i. Identification of maximum simultaneous dispatch for each renewable generator
        ii. Identification of limiting elements
        iii. Identification and testing of possible system upgrades
        iv. Repeat until the 33% RPS goal is attained
    c. Upgrade case analysis
        i. Thermal
        ii. Post-transient voltage
        iii. Transient stability
        iv. Reactive margin adequacy
    d. Final system topology
4. Report

V. STUDY SCHEDULE

The following table indicates the proposed study schedule.

Task	Completion Date
Final Study Plan available for Stakeholder comment	*July 22, 2009*
Stakeholder Pre-Meeting (San Francisco)	*August 10, 2009*
Stakeholder Meeting (San Francisco) (Review Study Plan/Assumptions)	*August 11, 2009*
Complete Base Case Development	*August 15, 2009*
Complete Technical Studies	*November 2, 2009*
Study Presentation to Exec Committee	*November 13, 2009*
Draft Report	*December 5th, 2009*
Stakeholder Meeting (Present Draft Results)	*TBD*
Final Report	*January 15, 2010*

APPENDICES

Study Report Draft Outline

I EXECUTIVE SUMMARY

II INTRODUCTION AND OBJECTIVES

III SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

IV WECC PROCESS FOLLOWED

V BASE CASE ASSUMPTIONS

VI DETAILED STUDY METHODOLOGY
Power Flow Analyses
Stability Analyses
Post-transient Analyses

VII STUDY RESULTS

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- Contingency Analysis Tables
- Stability Analysis Tables
- Post-transient Analysis Tables

SUMMARIES
- Major Flows

FIGURES
- Power Flow Diagrams
- Stability Plots

MEETING RECORDS
- List of participants
- Meeting Notes

STUDY PLAN
