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Solution to Reliability Issues in Southern California

The Nevada hydro Company is developing the 500 MW Lake Elsinore Advanced Pumped Storage (LEAPS) project located barely 20 miles from SONGS. It is also developing a 500 kV transmission line connecting SCE and SDG&E at 500 kV for the first time. This line now terminates barely 10 miles from SONGS. The Company has prepared three whitepapers that describe in detail how these two projects SOLVE the reliability problems facing Southern California.
We are providing them to this proceeding to that the Commission will have a full understanding of what is available, that is in accord with the Governor's mandates to reduce GHG emissions.
This filing provides the 3rd Whitepaper of 3.

Additional submitted attachment is included below.

Making the Most
of the
Lake Elsinore Advanced Pumped Storage (LEAPS) Project

The Nevada Hydro Company

June 2015

This is the third in a series of Whitepapers providing the views of The Nevada Hydro Company and its experts on issues relating to the state of the high voltage grid in Southern California.

The **Lake Elsinore Advanced Pumped Storage** (LEAPS) project was visionary when conceived roughly 20 years ago. The perfect geography adjacent to Lake Elsinore makes for a world class energy storage project. Further, the location at the juncture of high voltage transmission lines from east to west and out of the San Onofre Nuclear Generating Station (SONGS) into southern California makes it ideal for distributing energy throughout Southern California. With the demise of SONGS, LEAPS is even more important today.

I. Background

Since its conception, the design of LEAPS has remained largely unchanged while much has changed in the world in which the project sits. For example:

- California is now implementing compliance with a 33% Renewable Portfolio Standard by 2020 for its investor owned utilities, publicly owned utilities, and other retail sellers of electricity that will shift a large portion of future generation (largely solar and wind resources) to the east. Previously, most of the area's electricity had been produced along the Pacific coast.
- In 2008, the California State Water Resources Control Board implemented a regulation that has required electric generating stations using ocean water for their cooling requirements to either remediate the impacts of such use or to cease operations by the end of 2017. As much of the present generation for southern California is coastal, this will result in a major loss of existing generation in southern California, causing

large changes in the flow of energy in the region. Where energy flows had largely been west to east, it is now shifting to become east to west.[1]

- The high voltage electric grid in the area where LEAPS connects has been radically changed by the retirement of the SONGS facility. This retirement has caused two major issues:
  - The reliability of the transmission system to import power into San Diego load has been significantly diminished; and,
  - The ability of the system to maintain voltage has been significantly reduced because the power to serve load must be delivered from further away.

II. Southern California Reliability Problems

As a result of the above changes, southern California is facing significant reliability problems. The California Independent System Operator (CAISO), responsible for developing and operating the high voltage grid, has published three plans over the last few years in which it has addressed this reliability issue:

- The 2012-13 Transmission Plan lists the reliability shortfalls stemming from the shutdown of SONGS, before any remediation steps have been implemented.
- The 2013-14 Transmission Plan included some remediation plans, but did not provide definitive plans that would bring the area into reliability compliance.
- The Draft 2014-15 Transmission Plan has continued to move the system toward compliance[2] by including a remediation package known as the "South of SONGS Safety Net". The plan relies on "load shedding",[3] designed to maintain operation of the overall system at the expense of selected areas which would have their power switched off. The plan also proposed the installation of a specialized power flow controlling transformer in Imperial Valley designed to moderate line flows through the electric system in Mexico. Together, this "Safety Net" will provide reliable operation

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[1] / For further information, the California Energy Commission is tracking this continuing process addressing coastal power plants using "once–through–cooling". See, for example, http://www.energy.ca.gov/renewables/tracking_progress/documents/once_through_cooling.pdf.

[2] / System reliability standards are imposed on operators like the CAISO by the North American Electric Reliability Corporation (NERC) and by the Western Electricity Coordinating Council (WECC).

[3] / As it sounds, "load shedding" is intended to keep the electric system stable and running during emergencies by cutting off power to consumers in selected areas, thereby reducing demand on the system.

within southern California area until the Encina power plant[4] is retired at the end of 2017, not even 2 years off.

III. How LEAPS and its interconnecting 500 kV transmission line[5] fit in

The original plans for LEAPS, dating from 2008, include two connection points. First, a connection to the SCE system to the north of the facility. The southern terminus, which is the interface with the San Diego Gas & Electric (SDG&E) system at a point to be called Case Springs, is located on the existing Talega-Escondido 230 kV line right-of-way roughly 14 miles from the Talega substation, just up the hill from SONGS. Thus, as originally proposed, LEAPS connects to SCE's system at 500 kV and to SDG&E's system at only 230 kV to match the voltage of the existing Talega-Escondido line.

Because the original proposed connection with SDG&E at Case Springs was to be at 230 kV, the LEAPS 500 kV connection to the south terminated in a substation consisting of a set of three transformer trains[6] to move power from the 500 kV line coming from LEAPS to the lower voltage, 230 kV SDG&E system. Studies SDG&E conducted for this connection found that the present single circuit 230 kV line from Talega to Escondido would be inadequate for the potential power flows that would result from the connection with LEAPS. So, SDG&E included a requirement for the connection that the 51 miles of 230 kV line between Talega and Escondido be reconstructed for two circuits, each with two conductors per phase to better accommodate LEAPS.

It turns out that this design, although created decades ago, allows the grid to remain in compliance with the NERC/WECC reliability criteria both before and after SONGS was retired, but only while Encina is still in service. With both SONGS and Encina retired, this original configuration for the southern connection (along with the CAISO approved phase shifting transformer at Imperial Valley) is only just barely able to provide reliability to the system. The CAISO's proposed South of SONGS Safety Net could still be a potentially useful tool to meet unplanned problems, as southern California found out in the blackout of September 2011. But

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[4] / The Encina Power Station is an old, large natural gas fueled power plant located on the coast at Carlsbad, California. The facility is owned by NRG Energy and produces nearly 1,000 MW.

[5] / Note that LEAPS could connect to just the SCE system, just the SDG&E system or to both systems. LEAPS has valid agreements with each utility allowing for these connection combinations. LEAPS could also connect to the grid through a proposed high voltage (500 kV) transmission line that mirrors the routes of each individual connection for LEAPS, but which would also directly tie the SCE and SDG&E systems for the first time at this voltage level. This transmission line would need to be separately approved by regulators.

[6] / Each transformer set included a "step–down" transformer to convert the voltage coming from LEAPS to the lower 230 kV of the Talega–Escondido corridor. Each set was to also include a phase-shifting transformer that could control the power flow across the connection. This specialized transformer can change the effective phase displacement between the input voltage and the output voltage, thus controlling the amount of active power that can flow in the line.

of course this plan requires that areas be disconnected (blacked out) from the grid to keep the remaining grid functioning. This is obviously not an optimal solution for the California economy or for individuals who could have their power shut off.

As demand in Southern California continues to grow and the once-through cooling generation retirements take effect, the need for either additional transmission into or local generation within the L.A. Basin and San Diego load pocket increases. In its 2013-14 Transmission Plan, CAISO described a number of large transmission projects as potentially helping to alleviate the reliability concerns.

However, in its plan for the following year (2014-15), the CAISO dropped most of the proposed transmission projects it had identified, explaining that it is expecting generation additions approved by the Public Utilities Commission (PUC), in combination with the few small transmission projects it approved in the previous plan, will meet all reliability needs for the area. As CAISO noted however, there is no assurance as to whether it will be possible to complete the generation additions the PUC authorized. Potential obstacles to such completion include obtaining required permits and approvals. Significantly, (i) a head–to–head comparison of the financial and environmental cost of reliability fixes through additions of transmission or generation resources has not been done and, (ii) the CAISO continues to consider the use of the Talega-Escondido right-of-way as part of LEAPS and as a 230 kV corridor, as shown in its diagram of the Project in the draft 2014-15 Transmission Plan.

The CAISO has also initiated a process to deliver up to an additional 1,500 MW of renewable energy from the Imperial Valley area to the L.A. Basin and San Diego over and above what is already flowing. This appears to be in conflict with the conclusion that the PUC–approved generation will fill the reliability requirement, even if it is important to be able achieve maximum renewable generation delivery. The conflict over how to manage the use of renewables, conventional generation and preferred resources appears to be a work in progress.

Since shortly after SONGS was shut down but before its retirement was announced, the LEAPS project developer has been suggesting[7] that the Talega-Escondido corridor should be upgraded to 500 kV, rather than kept at its existing 230 kV level. Recognizing that the LEAPS developer only has the power to <u>suggest</u> how the system beyond the LEAPS interconnection points might be developed, the following includes these suggestions in high level form, with a technical addendum to support these ideas attached.

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[7] / See, "Summary of Future Transmission Needs in Southern California", a whitepaper prepared by The Nevada Hydro Company, June 27, 2014.

IV. What can be done?

If one were to consider the 500 kV line extending from LEAPS to the SDG&E system as a giant extension cord with the plug at the southern end (Case Springs) to be designed to integrate with whatever transmission SDG&E and the CAISO may plan for the Talega-Escondido corridor, what might be done with this cord that would improve system reliability at low cost and in a short time?

The following presents some suggestions:

A. Talega-Escondido Corridor Upgrade

Upgrade the Talega-Escondido corridor to a 500 kV 4,000 amperes line, with the Talega and Escondido substations upgraded to 500/230 kV step-down points with each having at least two 1120 MVA transformers. This single simple change will more than mitigate the reliability issues in the San Diego area. This change will also provide a major building block for transmission additions in the SCE L.A. Basin.

The cost to implement this plan is minimal: The incremental cost to SDG&E for moving elements of the planned changes is relatively low. Case Springs substation would now be a three terminal 500 kV substation without transformers, a major cost reduction. The addition of large transformers at Talega and Escondido, the rebuilding of the existing towers and wires for 500 kV operation between Talega, Case Springs, and Escondido, and expanding Talega to reconnect the SCE 230 kV lines coming out of SONGS and going to Santiago, Viejo, and Serrano would be the major cost elements. The Talega-Escondido corridor would need to be re–permitted to allow for this higher voltage.

B. Escondido-Suncrest 500 kV line

As the CAISO shows in its draft 2014-15 Transmission Plan[8], it has anticipated a new transmission connection between Escondido and Suncrest. This path appears to be planned as a 230 kV line(s), but could be built as a high capacity 500 kV line, connecting at 500 kV to the Talega-Escondido upgrade described in the previous subsection.

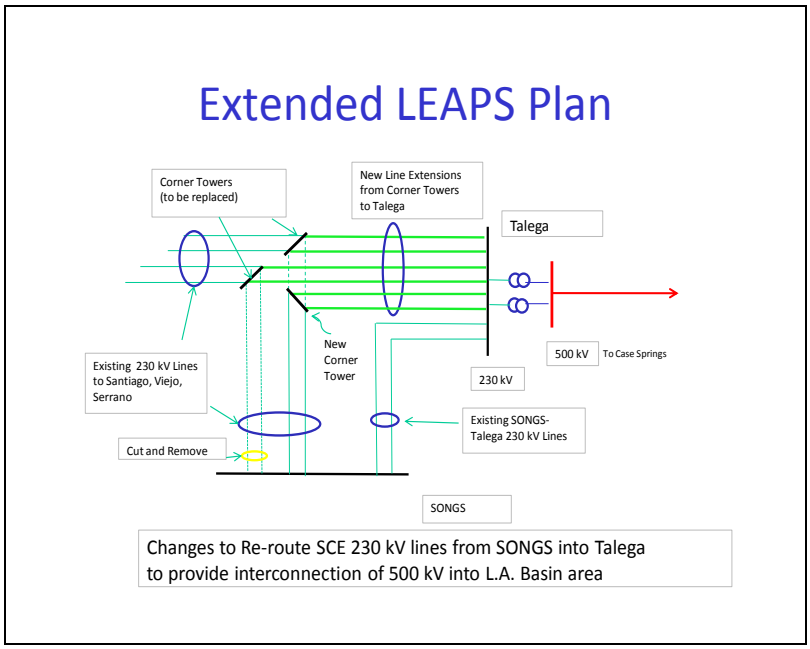
C. Talega Substation Expansion

The suggested 500 kV addition to the Talega Substation provides considerable import capability to SDG&E. Also, as a first step toward being able to improve delivery capability into SCE's L.A. Basin service area, the advantageous location of several of SCE's 230 kV high capacity lines very near the Talega Substation on their path to SONGS provides an

[8] / See Figure. 2.6-5 (High-level Illustrations of Potential Backup Transmission Solutions) in the CAISO 2014-15 Transmission Plan.

opportunity to reconnect them to a new strong source. This change is illustrated conceptually in Figure 1 – Suggested changes to the Talega Substation.

Figure 1 – Suggested changes to the Talega Substation



As can be seen in Figure 2 – Aerial View of Talega Substation Area, the distances for this change of transmission line routings is quite short, only about 0.4 miles. And there seems to be adequate land between the existing Talega Substation and the SCE 230 kV lines to develop the substation expansion.

Figure 2 – Aerial View of Talega Substation Area

D. Felicity-Colorado River 500 kV Line

The CAISO has noted[9] the need to be able to move power from the area along the Southwest Power Link (SWPL) to the path of the Palo Verde-Colorado River-Devers 500 kV lines, and vice versa. Arizona does not appear to wish to allow California-based utilities the ability to double circuit those 500 kV paths in Arizona. Yet, there is a strong need to be able to move large blocks of power between the northern 500 kV route in California and the SWPL path. California utilities, CAISO and the California regulators have made past attempts to close this gap but have not yet been successful.

Yet, there appears a relatively short (60 miles, +/-) easy-to-permit path already existing. This is a 500 kV line from the area just inside the California border west of North Gila (32° 46'N, 114° 50'W), dubbed "Felicity" in the local area, to the Colorado River Substation. This line would use an existing right-of-way for most of its length presently used by WAPA at 161 kV. WAPA has expressed willingness for such a use in the past as long as it was able to deliver its requirements to its customers through an underbuild on the new line or other arrangement. The area of the line is largely empty desert, as can be seen in Figure 3 – Suggested line from Felicity to Colorado River Substation.

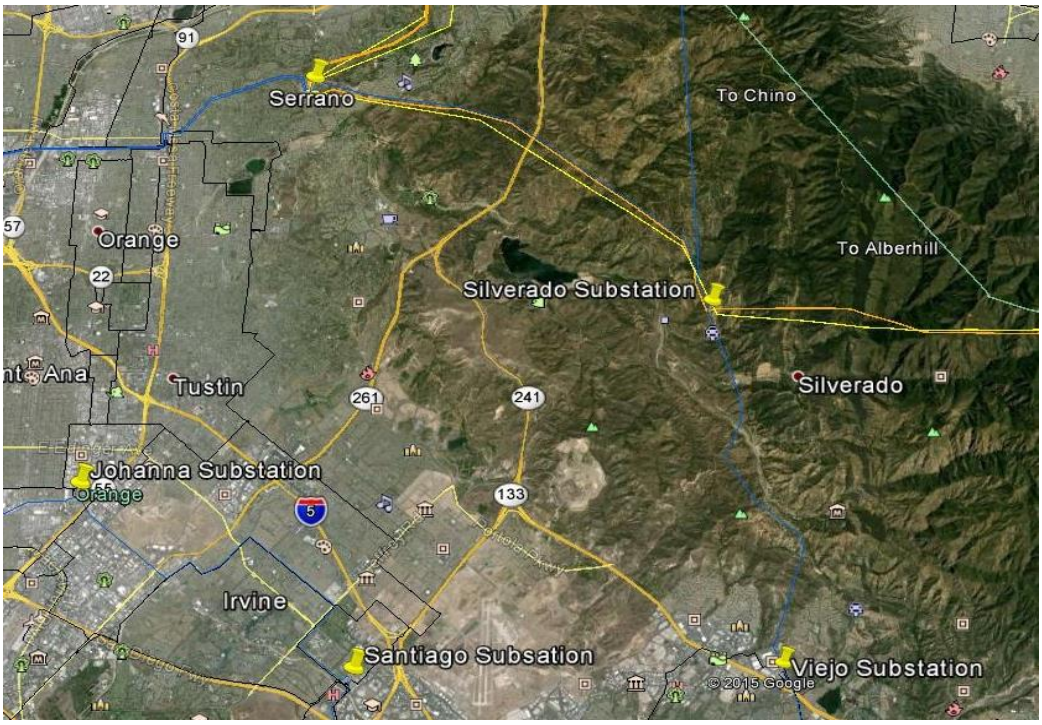
Figure 3 – Suggested line from Felicity to Colorado River Substation

[9] / CAISO Draft 2014-15 Transmission Plan, page 99.

E. Silverado 500/230 kV Substation

The existing Valley-Alberhill-Serrano 500 kV line passes through a point (33°45'55"N, 117°39'52"W) where two 230 kV lines also pass, the Serrano-SONGS line and the Viejo-Chino line. This area is shown on Figure 4 – Proposed Silverado Substation and Interconnecting 230 kV Substations.

Figure 4 – Proposed Silverado Substation and Interconnecting 230 kV Substations



The proposed development of a substation at this point could include the following:

- Establish a 500/230 kV stepdown substation with two or three transformers (SCE/CAISO's choice)
- Replace the existing 230 kV line from Serrano to SONGS north of Silverado with a new 500 kV line from Serrano to Silverado
- Replace the existing 230 kV line from Serrano to SONGS south of Silverado with a new 500 kV line from Silverado to Talega
- Loop the Chino-Viejo 230 kV line into Silverado and add a second 230 kV circuit from Silverado to Viejo

- Extend a double circuit 230 kV line from Silverado to the junction point with the Santiago-Johanna 230 kV line at the turn at Jeffrey Road (33°41'04"N, 117°46'22"), split the existing Santiago-Johanna line and tie each open end into the new lines from Silverado
- Tie the 230 kV line from Ellis to Santiago that passes through the Johanna Substation into the Johanna 230 kV bus
- Optionally, add a second 500 kV line from Valley to Alberhill to Silverado

There appears to be an existing right of way along Jeffrey Road that goes from the junction point noted above to the edge of any development on the way to Silverado. The Silverado site is quite open, and may have been planned to be a substation someday.

F. Additional Combined Cycle Generation

The U.S. Environmental Protection Agency and California have a strong preference for replacement of gas-fired steam generation with gas-fired combined cycle generators, renewable resources and energy storage. However, with the addition of the suggested 500 kV line from Case Springs to Escondido, which passes through the CAISO-proposed Inland site (formerly the proposed Rainbow site), the potential siting of 1,000 to 1,500 MW of combined cycle generation now is feasible from a transmission perspective and a gas supply perspective.

V. Conclusion

The timing to complete the LEAPS 500 kV line and its interconnecting substation additions at Talega and Escondido would be at about the time Encina must retire and before the summer peak season of 2018, approximately three years. The timing of these follow-on additions to the LEAPS and Talega-Escondido 500 kV line and substations is a matter for further discussion. Some of these projects can be carried out in time parallel with LEAPS-Talega-Escondido, others will require more coordination and planning.

In short, we urge consideration of converting the Talega-Escondido line corridor to 500 kV, not keeping it at its now out–of–date 230 kV level.

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Making the Most
of the
Lake Elsinore Advanced Pumped Storage (LEAPS) Project

Technical Addendum

Power Flow modeling and results

This addendum is intended to provide the technical backup supporting the specific changes suggested in the main document.

Section I provides a description of the modeling undertaken and conclusions drawn therefrom. Section II describes the situation shown by the modeling undertaken. Section III provides detailed instructions for setting up and running the power flow models and Section IV provides the results, in graphic format, of the modeling undertaken.

I. Load flow modeling in support of conclusions

We undertook extensive load flow modeling that support our conclusions. This modeling was based, as the starting point, the electric load flow case developed by WECC for the 2018 Summer Heavy Load condition. This base case was then modified to take the San Onofre Nuclear Generating Station ("SONGS") out of service with SCE's system generation modified to replace its output. SCE's net tie flows were maintained at -7,231 MW.

Initial tests of this system showed that the N-1-1 loss of the Imperial Valley-Miguel 500 kV line followed by system generation adjustments and then the loss of the Imperial Valley-Suncrest 500 kV line resulted in voltage collapse in the entire San Diego load area and a large percentage of the SCE L.A. Basin area. The primary boundary point between the areas within SCE where service continued and where it was blacked out was at the Serrano Substation. This finding is consistent with the actual blackout event's results of September 2011.

A. CAISO 2013–2014 proposals adopted

The CAISO offered four proposals to improve reliability for this area in its 2013-14 Transmission plan:

- A phase shifting transformer added to the 230 kV line that runs from Imperial Valley Substation in SDG&E to Rosarita Substation in the CFE system in Mexico. This is planned to limit the flow over the CFE system in order to keep CFE's lines within rating while still providing some power delivery through CFE into the San Diego load area

- 450 MVAR of reactive power supplies be added in the northern SDG&E area or at the SONGS 230 kV bus
- Addition of the Mesa Substation 500 kV loop-in, using the Vincent Mira Loma 500 kV line that is part of the Tehachapi Transmission Project
- Conversion of two of the Huntington Beach power plant's units (#'s 3 & 4) to act as synchronous condensers, since they cannot be operated as real power generators for lack of emissions credits, which had been transferred to the new Walnut Gas turbine plant.

All of these CAISO proposals are assumed completed and in service by 2018, and have been included in modeling.

B. The LEAPS Interconnection Agreements

The Lake Elsinore Advanced Pumped Storage ("LEAPS") has 2 agreements allowing it to connect to the state's high voltage grid, one each with SCE and San Diego Gas & Electric ("SDG&E"). The connection consists of a 500 kV line from SCE's proposed Alberhill Substation (before Alberhill's development, this interconnection point was to be a tee-point Substation called "Lake" in the same vicinity), through the LEAPS powerplant at Lake Elsinore, and then to a 500 kV substation in the SDG&E service area. This substation is to be called "Case Springs".

The project developer and SDG&E agreed to an interconnection plan at the Case Springs Substation in 2008. The substation's configuration was to include a set of three 500 kV to 230 kV transformers and three 230 kV phase shifting transformers that would tie into SDG&E's Talega-Escondido 230 kV ("T–E") line. Analysis to support the Interconnection Agreement showed that it would be necessary to upgrade the existing 230 kV T–E line, which uses one side of a set of double-circuit towers, to double bundle the conductor, essentially doubling the line's capability, and to add a second circuit, also double bundled, on the other side of the towers. There were also other associated changes included in both the SCE and SDG&E interconnection agreements, which should be re-visited because the system has changed since the original connection configurations were created.

II. Current Situation

A few years after these connection configurations had been agreed to; the electrical landscape changed dramatically and permanently, first, with the shutdown of SONGS and then its retirement. Suddenly (in the timeframe of large scale generation and transmission planning), the southern California area, which is especially the entire SDG&E load area and the Los Angeles Basin area of SCE, was short of over 2,000 MW of what had been considered a rock-solid power source.

In addition, and perhaps more importantly, in 2008, the California State Water Resources Control Board began discussions on use of ocean and estuarine water for power plant cooling. A multi-agency policy on what became known as "Once-through-cooling" ("OTC") regulation was approved by the Office of Administrative Law and became effective on October 1, 2010.

The consequences of these two events are that the SDG&E and SCE L.A. Basin load areas were short of generation and would become more so when the full effects of the OTC regulations came into play beginning at the end of 2017. The OTC compliance plan for the 946 MW Encina Station in SDG&E's load area envisions full retirement by the end of 2017. The owners of the Alamitos Station in SCE's L.A. Basin, which has a required compliance date of December 31, 2020, have plans to meet compliance.[1] The owners of Huntington Beach, which still has units 1 and 2 (452 MW) operating has requested postponement of compliance from the end of 2020 to the end of 2022.

There are other generators in the L.A. Basin, some of which have already been repowered as air-cooled, or plan to do so, such as El Segundo units 3 and 4, and others, such as Long Beach, that have retired. SCE will also have generators not in the L.A. Basin area be retired, such as Mandalay (430 MW).

The consequences of the OTC regulations is that by the summer heavy load period of 2018, the SDG&E and L.A. Basin load areas will have lost at least 1,000 MW of generation in addition to the 2,150 MW from the SONGS retirement. By the summer heavy load period of 2021, the loss from OTC regulatory requirements will be over 2,000 MW (plus the 2,150 MW from the loss of SONGS), with the final number yet to be finalized.

As one might expect, there has been a major push to add new generation in the two areas. One project that has been proposed is the Carlsbad Project. Carlsbad was initially conceived as a combined cycle plant that would occupy part of the present Encina site. Now, it is to be a peaking power plant.

In CPUC proceedings known as the Long Term Procurement Plan (LTPP)[2], SDG&E has been authorized to procure 800 to 1,100 MW of new generation, of which a minimum amount of 175 MW must be preferred resources including energy storage, and a minimum of 25 MW must be storage resources. 600 MW to 900 MW may be from other resources. In that same proceeding SCE was authorized to procure 1,900 MW to 2,500 MW of new resources, of which a minimum of 50 MW must be from storage, 550 MW must be from preferred resources, up to 400 MW

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[1]/ Units # 5 and 6 (993 MW) to be retired at the end of 2019, changes to units 1 and 2 (350 MW) are delayed until the end of 2027 and changes to units 3 and 4 (668 MW) are delayed until the end of 2023.

[2]/ "Decision Authorizing Long-Term Procurement for Local Capacity Requirements Due to Permanent Retirement of The San Onofre Nuclear Generations Stations", Rulemaking R.12-03-14, Decision 14–03–004, March 13, 2014.

from optional additional preferred resources/energy storage, 1,000 MW from gas-fired generation, and 300 to 500 MW of any type resource.

The procurement authorizations for SDG&E and SCE were predicated on there not being adequate time for consideration of non-generation solutions for power to be delivered from outside the SDG&E and SCE L.A. Basin areas.[3] However, the order requires the utilities to follow the CPUC's loading order requirement. "[T]his clarified Loading Order is a departure from the Commission's previous position of procuring energy efficiency and demand response, then renewable energy, and then allowing "additional clean, fossil-fuel, central-station generation," because "preferred resources require both sufficient investment and adequate time to 'get to scale.'" Instead of procuring a fixed amount of preferred resources and then procuring fossil-fuel resources, the IOUs are required to continue to procure the preferred resources "to the extent that they are feasibly available and cost effective."[4]

Given this articulated time constraint, the order sets the activity in motion to procure whatever generation, within the constraints provided, can be built to fill the growing shortage.

In our view, there is a serious conflict between the two articulated goals:

1. Meet the reliability needs of the system; and,
2. Provide operational control of the system adequate to the high variability of the large amount of renewable generation.

The CAISO responded by submitting its "deterministic studies of the existing trajectory and 40% Renewable Portfolio Standards scenarios with no renewable curtailment."[5] The filing offers the following conclusions:

> *"With no curtailment of renewable resources, the CAISO identified upward and downward reserve and load following shortfalls and unsolved over-generation in both the Trajectory and 40% RPS in 2024 scenarios. The unsolved over-generation is significant in the 40% RPS in 2024 scenario. Simply adding more flexible generation resources cannot solve the problem. The frequency and magnitude of the reserve shortfalls and unsolved*

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[3]/ *Id.* at page 11: "As discussed herein, we determine that it is necessary to authorize additional procurement at this time. The 2013/2014 TPP results are expected to be complete by March 2014. However, further procedural activities in this docket would necessitate at least several months to fully develop a record to incorporate the new TPP results. With long lead-time resources requiring several years of effort, and potential reliability issues surfacing starting in 2018, we cannot wait for further information at this point."

[4]/ *Id.* at page 15.

[5]/ California Independent System Operator Corporation, Deterministic Studies, Rulemaking R.12-03-14, May 10, 2014.

over-generation reflect conditions that do not support reliable grid operations. As a result alternative options must be explored, including:

1) improving time of use rates to match with the pattern of over-generation;
2) targeting energy efficiency at hours without over-generation;
3) decarbonizing transportation fuels to create flexible load;
4) increasing demand response and storage;
5) allowing additional economic dispatch of renewables;
6) retrofitting of existing power plants to increase fleet flexibility; and
7) deepening regional collaboration through participating in the CAISO Energy Imbalance Market and increasing the CAISO operating footprint."

In our view, this somewhat academic and distant set of option recommendations does not recognize that the problem is upon California already and will grow into greater difficulties and unreliability as each year passes. This is in notable contrast to the urgency conveyed by Wellhead Electric Company for example, in its filing of May 10, 2015. Its conclusions in that filing are as follows.

"Our analysis shows an undisputed OG problem is likely to occur in 2019 (or perhaps earlier); much sooner than assumed in the traditional LTPP paradigm that is the basis of discontinuing Phase 1A. The Commission needs to acknowledge that a potentially serious renewable integration/OG problem could occur in 2019 (or even earlier) which has not been accounted for in the traditional LTPP paradigm. The time to act is now."

A. Suggestions for solutions to the "over-generation" problem

The reader may wonder what reasonably can be done. The first suggestion is that the CPUC should move aggressively to have storage facilities built as soon as possible. These facilities will allow management of the over-generation problem. It appears that the utilities operated by CAISO need a minimum of 1,000 MW of storage and eventually as much as 5,000 MW. This type of facility should have the advanced performance capabilities that offer short-term output control, such as can be seen already in the Dinorwig Project in Wales, and as proposed for the LEAPS Project.

The second suggestion is that additional transmission be added as soon as possible to provide supply to the San Diego and L.A. Basin load area from a much broader area, including out-of-state generation. This would mean increasing and integrating the 500 kV system supplying these two critically deficient areas. A first step in this process would be for CAISO, SDG&E, and SCE to take advantage of the 500 kV line proposed to interconnect the LEAPS Project so that would it connect to the SDG&E system and SCE's L.A. Basin system. This would change the long-discussed TE/VS line from being a generation interconnection line to being a

utility-owned line that happens to have LEAPS interconnecting at the utility interface. The potential of using the Talega-Escondido right-of-way as a 500 kV path and interconnection with a 500 kV line coming from LEAPS cannot be stressed enough, and the remainder of this Addendum addresses the use and benefits this plan provides.

1. Developments by Summer 2018

As a result of modeling and understanding of the operation of the southern California grid, we suggest that the following projects be undertaken before the summer of 2018:

- Develop the Talega-Case Springs-Escondido corridor for 500 kV with a rating of 4000 amperes.
- Build an expansion of Talega Substation designed to allow two 500 kV lines and eight 230 kV lines, with at least two 1120/1680 MVA 500/230 kV transformers
- Build an expansion of Escondido Substation designed to allow two 500 kV lines and four 230 kV lines, with at least two 1120/1680 MVA 500/230 kV transformers (If there is inadequate site space for such an expansion at the existing location, build a new 500/230 kV substation at an appropriate location north on the existing right-of-way of the existing Talega-Escondido 230 kV line, which already has the capability of connecting two high capacity 230 kV lines between the new location and Escondido.)
- Build a 500 kV line from The SCE Colorado River Substation south along the existing WAPA 161 kV line right-of-way to an intersection point with the Southwest Power Link 500 kV line in the Felicity area in California. The northern terminus of the line will require one additional position on the 500 kV bus at the Colorado River Substation. The southern terminus will require a new substation with three 500 kV line positions, and whatever stepdown/interconnection plans may come from new renewable energy projects located in the area requiring interconnection points.

We have prepared a set of computer files to be used with the PSS®E load flow program to add the several components suggested above to the WECC 2018 Heavy Summer load flow case after SONGS has been retired. Encina Station has been left operating in the case, and can be shut down as part of the performance testing of the proposed additions. These computer files, called “idv” files will accomplish the following:

- Install the 230 kV phase shifting transformer at Imperial Valley to control flow on the Imperial Valley-Rosarita line
- Install the Mesa 500/230 kV stepdown in SCE

- Install the LEAPS Project and the associated 500 kV lines from Alberhill to LEAPS to Case Springs.
- Install the 500 kV line from Talega to Case Springs to Escondido, and add the 500/230 kV equipment at each substation.
- Install the 500 kV line from Colorado River to Felicity Substation and the Felicity Substation, leaving the 53% series compensation on all 500 kV lines affected.

Subsequent to these additions, testing of the system's performance was conducted. Encina Station was shut down, with the generation replaced mostly from the Palo Verde area combined cycle plants and the rest from plants near Las Vegas. Then, tests of several N-1-1 contingency conditions were conducted. The pre-contingency conditions are shown in Section IV.A. The system performance with the N-1-1 losses of the Imperial Valley-Miguel and Imperial Valley-Suncrest 500 kV lines are shown in Section IV.B. A review of these test conditions shows that with both SONGS and Encina shut down there is no need for several years for either the Carlsbad or Pio Pico projects.

2. Developments by Summer 2021

By making the additions to the system for 2018 described above, system planners could move on to assess needs for upgrades/additions needed by summer 2021, as we have done. This testing consisted of using the same WECC 2018 heavy summer case with SONGS and Encina out of service and the several additions planned for 2018 also installed. Testing of this system condition found that there was need to find additional support for the 230 kV substations in the L.A. Basin. The LTPP process resulted in this case of adding four generation packages at Santiago (750 MW), Viejo (750 MW), Johanna (750 MW) and Ellis (500 MW). The need for these generation additions was apparently caused by the potential overload of one of the two 230 kV line from Serrano to Villa Park for the N-1-1 loss of one of the 230 kV lines from Serrano to Lewis and the loss of the other line from Serrano to Villa Park. After researching possible transmission options it was found that a new 500/230 substation would relieve the problem for an extended period of time. This new substation, dubbed "Silverado", is located at the junction of the 500 kV line from Serrano to Alberhill and the 230 kV lines from Viejo to Chino and Serrano to SONGS. An aerial view of this location is included above, along with longitude and latitude coordinates.

Again, the system equipment additions and changes for adding and integrating this new substation, as well as a 500 kV line from Suncrest to Escondido are included in "idv" files we can provide and are described in Section III. The base conditions after this set of additions are shown in Section IV. After adding this new substation and its associated lines, contingency testing was conducted. These tests showed that this upgrade of the

transmission system relieved the need for the four generation packages noted above. The limiting N-1-1 condition before the addition of Silverado was found to be fully relieved.

III. File Modification

This section provides the file modifications required to insert data for 2018 System Developments to run the cases discussed herein. The additions shown are "idv" files to be used with PSS®E, or the data can be converted to be used in PSLF. Electronic copies of these files are available upon request.

A. Add Alberhill Substation if not already in starting case

```
@! "ALBERHILL_Add.idv", generated on FRI, APR 17 2015
@!
BAT_BUS_DATA_2,24845,,24,240,74, 500.0,,,'ALBERHILL'
BAT_BUS_DATA_2,24845,,,,,,,-17.0,'ALBERHILL'
BAT_BRANCH_DATA,24138,24151,'1',0,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,24138,24845,'1',,,,74,,,, 0.0002900, 0.0065400, 0.48180, 3421.0, 4616.0, 3421.0,,,,, 31.0,,,,,;
BAT_BRANCH_DATA,24151,24845,'1',,,,74,,,, 0.0001600, 0.0036900, 0.27156, 3421.0, 4616.0, 3421.0,,,,, 13.0,,,,,;
```

B. Add Mesa Cal 500/230 kV Substation Upgrade

```
@! Mesa 500/230 Add
@! Loop in Vincent-Mira Loma 500 kV to Mesa
@! Loop into Mesa the existing Rio Honda-Laguna Bell 230 kV line
@! Loop into Mesa the existing Goodrich-Laguna Bell 230 kV line
@! Install three 500/230 kV transformers (1120/1680/1120 MVA)
@!
@! This idv file set up for 2018 heavy summer load flow case, following years may have different starting
configurations
@!
@! Add Mesa 500 kV Bus
BAT_BUS_DATA_2,24990,,24,240,140, 500.0,,-17.0,'MESA'
@!
@! Remove Mira Loma-Vincent 500 kV line
BAT_BRANCH_DATA,24092,24156,'1',0,,,,,,,,,,,,,,,,,,;
@!
@! Remove Laguna Bell-Goodrich 230 kV Line
BAT_BRANCH_DATA,24076,25001,'1',0,,,,,,,,,,,,,,,,,,;
@!
@! Remove Laguna Bell-Rio Hondo 230 kV Line
BAT_BRANCH_DATA,24076,24126,'1',0,,,,,,,,,,,,,,,,,,;
@!
@! Add Mira Loma-Mesa 500 kV Line
BAT_BRANCH_DATA,24092,24990,'1',,,74,,,, 0.0003420, 0.007900, 0.56770, 3464.0, 4616.0, 3464.0,,,,, 34.0,,,,,;
@! Add Vincent-Mesa 500 kV Line
BAT_BRANCH_DATA,24156,24990,'1',,,74,,,, 0.0004280, 0.009900, 0.71130, 3464.0, 4616.0, 3464.0,,,,, 42.6,,,,,;
@!
@! Mesa 500/230 kV transformers (set transformer voltage ratios after running idv file, set nominal to begin)
BAT_TWO_WINDING_DATA,24990,24091,'1',1,24091,74,,,,17,,24990,24090,,0,2,2,, 0.00000,
0.01319,1120.0,500.0,500.0,,230.0,230.0,1120.0,1680.0,,,,,,,,,,,,,'Mesa1'
BAT_TWO_WINDING_DATA,24990,24091,'2',1,24091,74,,,,17,,24990,24090,,0,2,2,, 0.00000,
0.01319,1120.0,500.0,500.0,,230.0,230.0,1120.0,1680.0,,,,,,,,,,,,,'Mesa2'
BAT_TWO_WINDING_DATA,24990,24091,'3',1,24091,74,,,,17,,24990,24090,,0,2,2,, 0.00000,
0.01319,1120.0,500.0,500.0,,230.0,230.0,1120.0,1680.0,,,,,,,,,,,,,'Mesa3'
```

```
@!
@! Laguna Bell-Mesa 230 kV Line 1
BAT_BRANCH_DATA,24076,24091,'1',,,74,,,, 0.0004520, 0.005539, 0.02092, 988.0, 988.0, 988.0,,,,, 5.2,,,,,;
@! Laguna Bell-Mesa 230 kV Line 2
BAT_BRANCH_DATA,24076,24091,'2',,,74,,,, 0.0004520, 0.005539, 0.02092, 988.0, 988.0, 988.0,,,,, 5.2,,,,,;
@!
@! Rio Hondo-Mesa 230 kV Line 2
BAT_BRANCH_DATA,24091,24126,'2',,,74,,,, 0.0009400, 0.012130, 0.04074, 988.0, 988.0, 988.0,,,,,10.6,,,,,;
@!
@! Goodrich-Mesa 230 kV line 1
BAT_BRANCH_DATA,25001,24091,'1',,,74,,,, 0.0007480, 0.009161, 0.03460, 988.0, 988.0, 988.0,,,,, 8.6,,,,,;
```

C. Add Colorado River Substation

```
@! text   Colorado River Substation and associated Colorado River 500 kV lines Add generated on FRI, APR 26
2015
@! text
@!  Remove 500 kV line section between first series comp bus 15023 and second series comp bus 15024
BAT_BRANCH_DATA,15023,15024,'1',0,,,,,,,,,,,,,,,,,,;
BAT_PURGBRN,15023,15024,'1'
@!
@!  Add Colorado River Sub bus
BAT_BUS_DATA,24900,1,24,248,74,,, 500.0,1.05,4.0,'Colo River'
@!
@!  Add Colo River lines to series comp buses 15023 and 15024
BAT_BRANCH_DATA,15023,24900,'1',1,24900,74,,,,0.0007100,0.016100,1.18260,3420.8,4615.9,3420.8,,,,,1,,,,;
BAT_BRANCH_DATA,24900,15024,'1',1,24900,74,,,,0.0003500,0.010390,0.76738,3950.0,4540.0,3950.0,,,,,1,,,,;
@!
@!  Restore buses 15022,15023,15024 and 15025 to service
BAT_BUS_DATA,15022,1,,,;
BAT_BUS_DATA,15023,1,,,;
BAT_BUS_DATA,15024,1,,,;
BAT_BUS_DATA,15025,1,,,;
@!
@!  Restore lines in multi-section PV-Devers 500 kV lines to service
BAT_BRANCH_DATA,15021,15022,'1',1,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,15022,15023,'1',1,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,15024,15025,'1',1,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,15025,24801,'1',1,,,,,,,,,,,,,,,,,,;
@!
@!  Add Multi section lines for PV-Colo River and Colo River-Devers
BAT_MULTI_SECTION_LINE_DATA,15021,24900,"&1",15021,15022,15023,,,,,,,,;
BAT_MULTI_SECTION_LINE_DATA,24900,24801,"&1",24900,15024,15025,,,,,,,,;
```

D. Add Felicity Substation and Felicity-Colorado River 500 kV line

```
@! text   Felicity_Substation_ and Felicity-Colorado River 500 kV line Add generated on FRI, APR 24 2015
@! text             Series Compensation set at 53% on all three lines
@! text
@! text   Remove 500 kV line and series compensation from N.Gila to Imperial Valley
@! text       line - 22536 to 22537  Comp - 22360 to 22537
BAT_PURGBRN,22536,22537, '1'
BAT_PURGBRN,22360,22537, '1'
@! text
BAT_BUS_DATA,22890,1,22,225,136,,, 500.0,1.05,4.0,'Felicity'
BAT_BUS_DATA,22891,1,22,225,136,,, 500.0,1.05,3.9,'Felcty&1'
BAT_BUS_DATA,22892,1,22,225,136,,, 500.0,1.05,3.8,'Felcty&2'
```

```
@! text
BAT_BRANCH_DATA,22536,22891,'1',1,22536,136,,,,0.000257,0.006609,0.49295,2598.0,2598.0,2598.0,,,,,1,,,,;
BAT_BRANCH_DATA,22891,22890,'1',1,22891,136,,,,0.000000,-0.00351,0.00000,1905.0,2572.0,1905.0,,,,,1,,,,;
BAT_BRANCH_DATA,22890,22537,'1',1,22890,136,,,,0.000493,0.012671,0.94511,2598.0,2598.0,2598.0,,,,,1,,,,;
BAT_BRANCH_DATA,22537,22360,'1',1,22537,136,,,,0.000000,-0.00673,0.00000,1905.0,2572.0,1905.0,,,,,1,,,,;
BAT_BRANCH_DATA,22890,22892,'1',1,22890,136,,,,0.000567,0.014573,1.08697,2598.0,2598.0,2598.0,,,,,1,,,,;
BAT_BRANCH_DATA,22892,24900,'1',1,22892,136,,,,0.000000,-0.00774,0.00000,1905.0,2572.0,1905.0,,,,,1,,,,;
@! text
BAT_MULTI_SECTION_LINE_DATA,22536,22890,"&1",22536,22891,,,,,,,,,
BAT_MULTI_SECTION_LINE_DATA,22890,22360,"&1",22890,22537,,,,,,,,,
BAT_MULTI_SECTION_LINE_DATA,22890,24900,"&1",22890,22892,,,,,,,,,
```

E. Add Imperial Valley – Rosarita 230 kV line phase shifter

```
@!     Add phase shifting transformer on Imperial Valley-Rosarita 230 kV line, APR 17 2015
@!
@!     Add new bus for phase shifter with assumed -4 degree angular position
BAT_BUS_DATA_2,22357,,22,225,136, 230.0,,,'Imp Val PS'
BAT_BUS_DATA_2,22357,,,,,,,-4.0,'Imp Val PS'
@!     take Imperial Valley-Rosarita line out of service and relocate IV end bus to Phase shifter bus
BAT_BRANCH_DATA,20118,22356,'1',0,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,20118,22357,'1',,,136,,,, 0.001000, 0.0099100, 0.03828, 786.7, 850.0, 796.7,,,,, 9.5,,,,,;
@!     Add phase shifting transformer with 10 degree phase angle offset as base condition, control flow in base
condition to 190-200 MW
BAT_TWO_WINDING_DATA,22356,22357,'P1',,22357,,,,,,15,,22357,,3,2,2,, 0.00071, 0.02663,, 230.0, 230.0,-10.0,
230.0, 230.0, 500.0, 620.0,,,,,,,, 32.0,-32.0, 200.0, 190.0,,,'IVPS1'
```

F. LEAPS and Enhanced TE-VS with Talega-Escondido 500 kV after Alberhill already in place as bus 24845

```
@! LEAPS and TE/VS Add
@! Updated to ADD EnhancedTE/VS-LEAPS with Alberhill 500 already in case as bus 24845
@! Updated to add enhanced Telega to Case Springs to Escondido 500 kV line with Rainbow Sub  3/11/15
@! Updated to add reconfiguration of SCE 230 kV lines into Talega with two 500/230 Xfmrs 3/11/15
@! For use in 2018 case and thereafter 3/11/15
BAT_OWNER_DATA,140,'TNHC'
BAT_BUS_DATA_2,99104,,24,240,140, 500.0,,-17.0,'LEAPS'
BAT_BUS_DATA_2,99110,2,24,240,140, 20.0, 1.05,-5.0,'ELSNORE1'
BAT_BUS_DATA_2,99112,2,24,240,140, 20.0, 1.05,-5.0,'ELSNORE2'
BAT_BUS_DATA_2,99115,,24,240,140, 500.0,,-18.0,'CASESPGS500'
BAT_Bus_Data_2,22845,,22,226,136, 500.0,,-18.0,'Talega500'
BAT_BUS_DATA_2,99130,,22,226,136, 500.0,,-18.0,'Rainbow500'
BAT_BUS_DATA_2,99131,,22,226,136, 500.0,,-18.0,'Escondido'
@! Alberhill-LEAPS 500 kV
BAT_BRANCH_DATA,24845,99104,'1',,,140,,,, 0.0001270, 0.0028867, 0.21258, 3464.0, 4616.0, 3464.0,,,,, 11.4,,,,,;
@! LEAPS-Case Springs 500 kV
BAT_BRANCH_DATA,99104,99115,'1',,,140,,,, 0.0002205, 0.0050138, 0.36922, 3464.0, 4616.0, 3464.0,,,,, 19.8,,,,,;
@! Remove Talega-Escondido 230 kV
BAT_BRANCH_DATA,22260,22844,'1',0,,,,,,,,,,,,,,,,,,;
@! Case Springs-Talega 500 kV
BAT_BRANCH_DATA,22845,99115,'1',,,136,,,, 0.0001599, 0.0035451, 0.26107, 3464.0, 4616.0, 3464.0,,,,, 14.0,,,,,;
@! Case Springs-Rainbow 500 kV
BAT_BRANCH_DATA,99115,99130,'1',,,136,,,, 0.0001893, 0.0043047, 0.31701, 3464.0, 4616.0, 3464.0,,,,, 17.0,,,,,;
@! Rainbow-Escondido 500 kV
BAT_BRANCH_DATA,99130,99131,'1',,,136,,,, 0.0002228, 0.0050644, 0.37295, 3464.0, 4616.0, 3464.0,,,,, 20.0,,,,,;
@! LEAPS Generator stepup transformers
```

BAT_TWO_WINDING_DATA,99104,99110,'1',,99110,140,,,,17,,,,,0,2,2,, 0.00541, 0.13,, 500.0, 500.0,, 20.0, 20.0,375.0,375.0,,,,,,,,,,,,'LEAPS1'
BAT_TWO_WINDING_DATA,99104,99112,'1',,99112,140,,,,17,,,,,0,2,2,, 0.00541, 0.13,, 500.0, 500.0,, 20.0, 20.0,375.0,375.0,,,,,,,,,,,,'LEAPS2'
@! Talega 500/230 kV transformers
BAT_TWO_WINDING_DATA,22844,22845,'1',,22845,136,,,,17,,22845,22844,,0,2,2,, 0.0, 0.01413,1120.0,525.0,525.0,,230.0,230.0,1120.0,1344.0,1680.0,1,,,,,,,,,,'Tal1'
BAT_TWO_WINDING_DATA,22844,22845,'2',,22845,136,,,,17,,22845,22844,,0,2,2,, 0.0, 0.01413,1120.0,525.0,525.0,,230.0,230.0,1120.0,1344.0,1680.0,1,,,,,,,,,,'Tal2'
@! Escondido 500/230 kV transformers
BAT_TWO_WINDING_DATA,22260,99131,'1',,99131,136,,,,17,,99131,22260,,0,2,2,, 0.0, 0.01413,1120.0,525.0,525.0,,230.0,230.0,1120.0,1344.0,1680.0,1,,,,,,,,,,'Esc1'
BAT_TWO_WINDING_DATA,22260,99131,'2',,99131,136,,,,17,,99131,22260,,0,2,2,, 0.0, 0.01413,1120.0,525.0,525.0,,230.0,230.0,1120.0,1344.0,1680.0,1,,,,,,,,,,'Esc2'@! LEAPS generation data
BAT_PLANT_DATA,99110,, 1.05,,;
BAT_PLANT_DATA,99112,, 1.05,,;
BAT_MACHINE_DATA_2,99110,'1',0,140,,,,, 0.0, 0.0, 122.0,-122.0, 250.0,-300.0, 360.0,, 0.22,,,,,,,,;
BAT_MACHINE_DATA_2,99112,'1',0,140,,,,, 0.0, 0.0, 122.0,-122.0, 250.0,-300.0, 360.0,, 0.22,,,,,,,,;
BAT_LOAD_DATA,99110,'1',,,,, 1.166, 0.723,,,,,;
BAT_LOAD_DATA,99112,'1',,,,, 1.166, 0.723,,,,,;
@! Talega 230 kV bus realignment
@! SONGS-Serrano, Santiago, Viejo lines switched off
BAT_BRANCH_DATA,24131,24137,'1',0,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,24131,24134,'1',0,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,24131,24134,'2',0,,,,,,,,,,,,,,,,,,;
BAT_BRANCH_DATA,24131,25654,'1',0,,,,,,,,,,,,,,,,,,;
@! New SONGS-Talega 230 kV lines added
BAT_BRANCH_DATA,22844,24131,'3',,,, 24,,,, 0.000365, 0.006613, 0.025997, 1195.0, 1315.0, 1315.0,,,,, 6.9,,,,,;
BAT_BRANCH_DATA,22844,24131,'4',,,, 24,,,, 0.000365, 0.006613, 0.025997, 1195.0, 1315.0, 1315.0,,,,, 6.9,,,,,;
@! New Talega-Serrano, Santiago, Viejo lines added
BAT_BRANCH_DATA,22844,24137,'1',,,, 24,,,, 0.002280, 0.041320, 0.162480, 1195.0, 1315.0, 1315.0,,,,,33.2,,,,,;
BAT_BRANCH_DATA,22844,24134,'1',,,, 24,,,, 0.001630, 0.029470, 0.115880, 1195.0, 1315.0, 1315.0,,,,,21.5,,,,,;
BAT_BRANCH_DATA,22844,24134,'2',,,, 24,,,, 0.001630, 0.029470, 0.115880, 1195.0, 1315.0, 1315.0,,,,,21.5,,,,,;
BAT_BRANCH_DATA,22844,25654,'1',,,, 24,,,, 0.001260, 0.028300, 0.089720, 1195.0, 1315.0, 1315.0,,,,,16.8,,,,,;

G. Add Suncrest-Escondido 500 kV line

@! Add new 500 kV line from Suncrest to Escondido
@!
@!
BAT_BRANCH_DATA,22737,99131,'1',,,136,,,, 0.000562, 0.0099341, 0.78865, 2598.0, 2598.0, 2598.0,,,,, 42.0,,,,,;

H. Add Silverado 500/230 kV Substation Upgrade

@! Silverado 500/230 kV Substation Add
@!
@! For use in 2018 case and thereafter 6/8/15
@! Use after running LEAPS_Enhanced_TE-VS_Add_After_Alberhill_Talega_Escondido_6-9-15.idv
@!
@! Add Silverado 500 and 230 kV buses
BAT_BUS_DATA_2,24980,,24,240,74, 500.0,,-14.0,'SILVRADO500'
BAT_BUS_DATA_2,24981,,24,240,74, 230.0,,-18.0,'Silvrado230'
@!
@! Remove Alberhill-Serrano 500 kV line
BAT_BRANCH_DATA,24845,24138,'1',0,,,,,,,,,,,,,,,,,,;
@!
@! Remove Serrano-Talega 230 kV

```
BAT_BRANCH_DATA,22844,24137,'1',0,,,,,,,,,,,,,,,,,,;
@!
@!  Add Alberhill-Silverado 500 kV and Serrano-Silverdo 500 KV (2 lines)
BAT_BRANCH_DATA,24845,24980,'1',,,74,,,, 0.0001840, 0.0041500, 0.305550, 3464.0, 4616.0, 3464.0,,,,, 16.6,,,,,;
BAT_BRANCH_DATA,24138,24980,'1',,,74,,,, 0.0001000, 0.0022480, 0.165480, 3464.0, 4616.0, 3464.0,,,,,  9.0,,,,,;
BAT_BRANCH_DATA,24138,24980,'2',,,74,,,, 0.0001000, 0.0022480, 0.165480, 3464.0, 4616.0, 3464.0,,,,,  9.0,,,,,;
@!
@!  Add Talega-Silverado 500 kV
BAT_BRANCH_DATA,22845,24980,'1',,,74,,,, 0.0001730, 0.0039000, 0.287150, 3464.0, 4616.0, 3464.0,,,,, 15.6,,,,,;
@!
@!  Add three Silverado 500/230 kV transformers
BAT_TWO_WINDING_DATA,24980,24981,'1',,24980,74,,,,17,,24980,24981,,0,2,2,, 0.0,
0.01413,1120.0,525.0,525.0,,230.0,230.0,1120.0,1344.0,1680.0,1,,,,,,,,,,'Silv1'
BAT_TWO_WINDING_DATA,24980,24981,'2',,24980,74,,,,17,,24980,24981,,0,2,2,, 0.0,
0.01413,1120.0,525.0,525.0,,230.0,230.0,1120.0,1344.0,1680.0,1,,,,,,,,,,'Silv2'
BAT_TWO_WINDING_DATA,24980,24981,'3',,24980,74,,,,17,,24980,24981,,0,2,2,, 0.0,
0.01413,1120.0,525.0,525.0,,230.0,230.0,1120.0,1344.0,1680.0,1,,,,,,,,,,'Silv3'
@!
@!  Remove Ellis-Santiago 230 kV line
BAT_BRANCH_DATA,24044,24134,'1',0,,,,,,,,,,,,,,,,,,;
@!
@!  Remove Chino-Viejo 230 kV line
BAT_BRANCH_DATA,24025,25654,'1',0,,,,,,,,,,,,,,,,,,;
@!
@!  Add Two Silverado-Viejo 230 kV Lines (one existing, one new)
BAT_BRANCH_DATA,24981,25654,'1',,,74,,,, 0.0004610, 0.0081270, 0.031950, 1195.0, 1339.0, 1195.0,,,,,,,,,,;
BAT_BRANCH_DATA,24981,25654,'2',,,74,,,, 0.0004610, 0.0081270, 0.031950, 1195.0, 1339.0, 1195.0,,,,,,,,,,;
@!
@!  Add Silverado-Santiago 230 kV
BAT_BRANCH_DATA,24134,24981,'1',,,74,,,, 0.0007980, 0.0146000, 0.057460, 1195.0, 1279.0, 1195.0,,,,,,,,,,;
@!
@!  Add Silverado-Johanna 230 kV
BAT_BRANCH_DATA,24072,24981,'1',,,74,,,, 0.0009680, 0.0177800, 0.069680, 1195.0, 1279.0, 1195.0,,,,,,,,,,;
@!
@!  Add Silverado-Chino 230 kV
BAT_BRANCH_DATA,24025,24981,'1',,,74,,,, 0.0010390, 0.0183100, 0.071990, 1195.0, 1339.0, 1195.0,,,,,,,,,,;
@!
@!  Add Ellis-Johanna Ckt 2 230 kV
BAT_BRANCH_DATA,24044,24072,'2',,,74,,,, 0.0003600, 0.0061000, 0.028000, 1195.0, 1279.0, 1195.0,,,,,,,,,,;
@!
@!  Add Johanna-Santiago 230 kV
BAT_BRANCH_DATA,24044,24072,'1',,,74,,,, 0.0004700, 0.0086000, 0.033850, 1195.0, 1279.0, 1195.0,,,,,,,,,,;
```

IV. Power Flow Diagrams

This section provides copies of power flow diagrams illustrating the cases described herein.

A. Power flow diagrams for 2018 system heavy load conditions

1. Under System Normal Conditions, the following projects have been added:

a) Mesa Cal 500/230 kV Substation

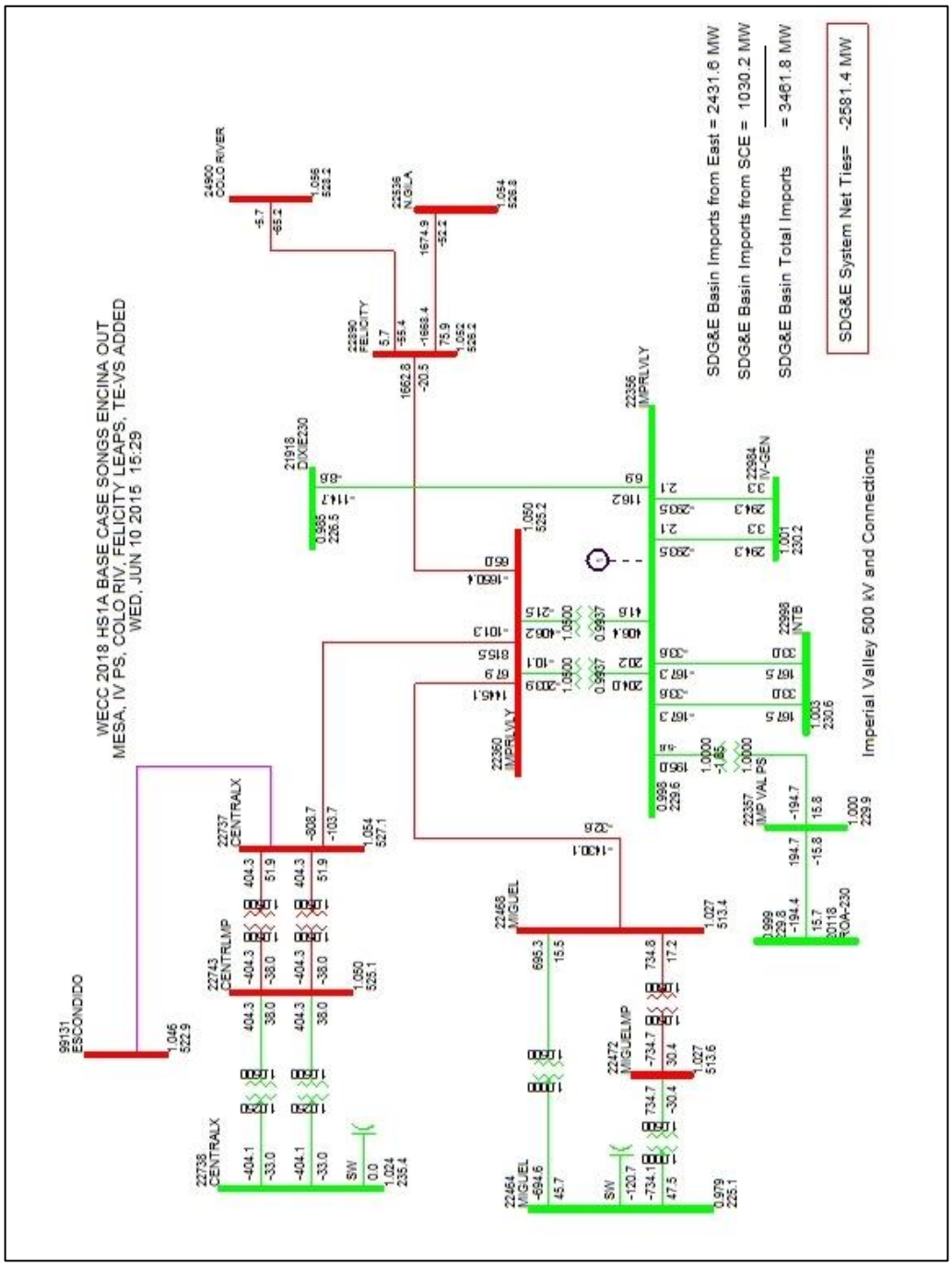
b) Colorado River Substation

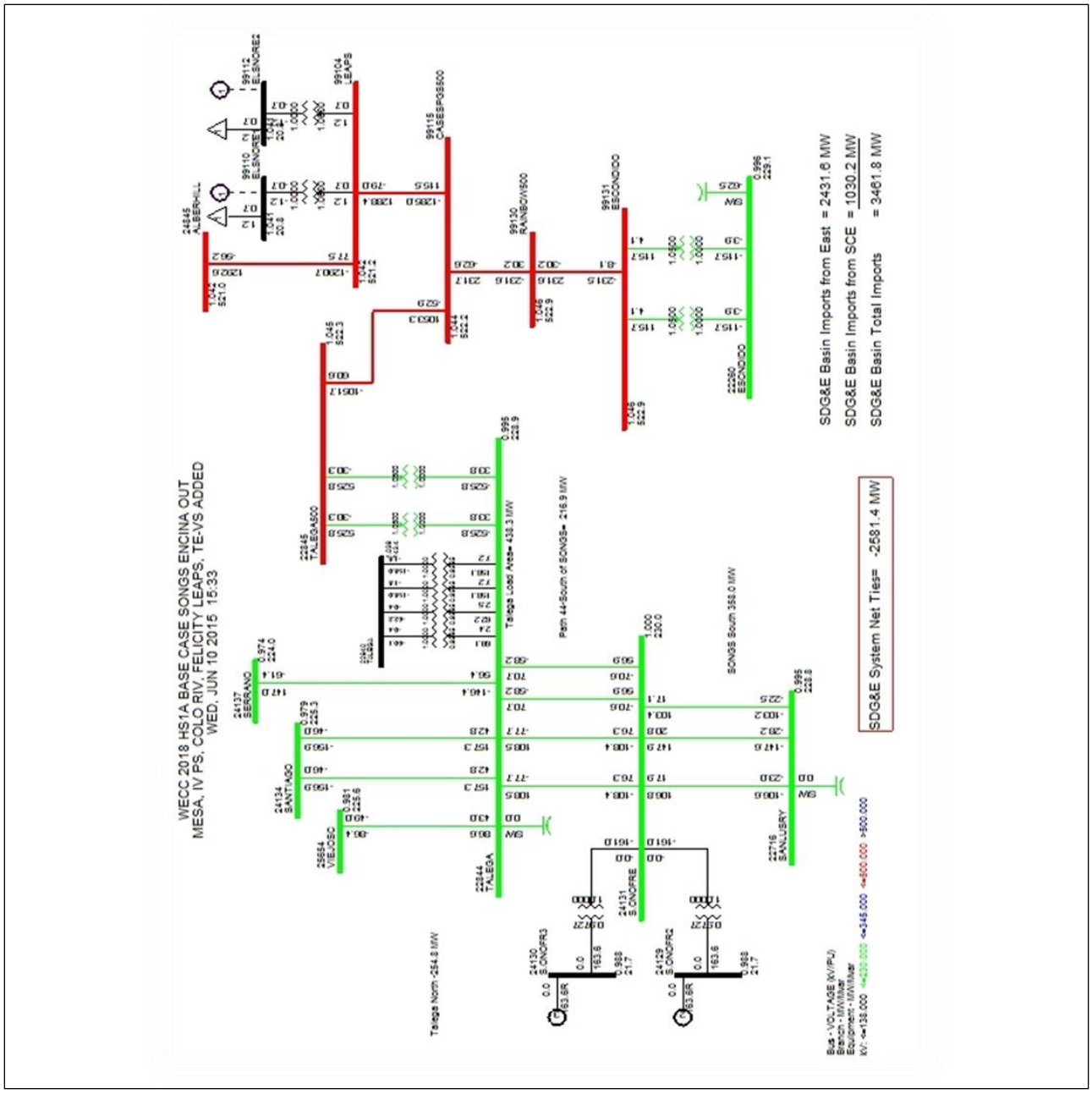
c) Felicity Substation and Felicity-Colorado River 500 kV line

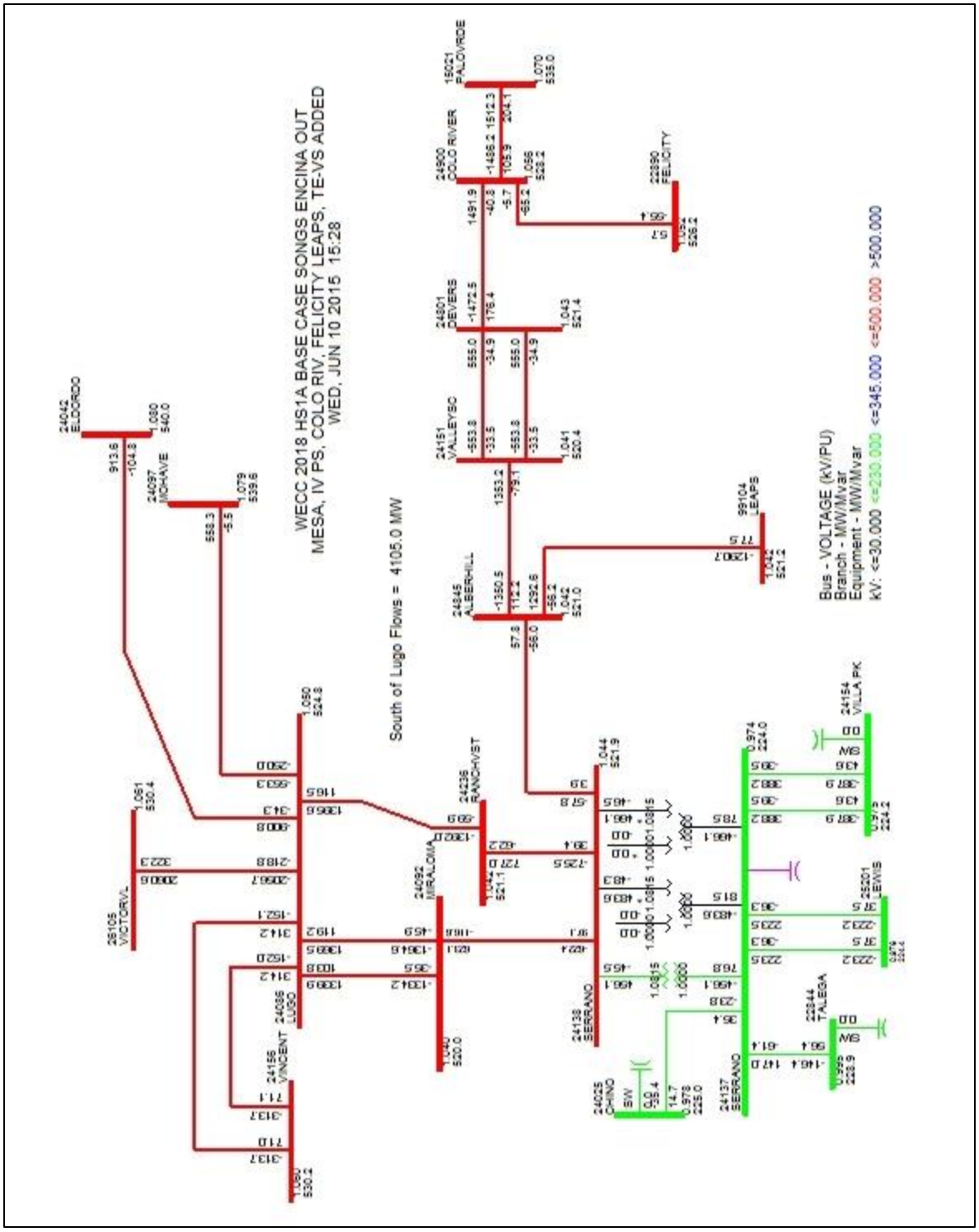
d) Imperial Valley-Rosarita 230 kV Line Phase Shifter

e) LEAPS

f) Enhanced TE-VS




WECC 2018 HS1A BASE CASE SONGS ENCINA OUT
MESA, IV PS, COLO RIV, FELICITY LEAPS, TE-VS ADDED
WED, JUN 10 2015 15:33
SDG&E Basin Imports from East = 2431.6 MW
SDG&E Basin Imports from SCE = 1030.2 MW
SDG&E Basin Total Imports = 3461.8 MW
SDG&E System Net Ties= -2581.4 MW
Talega Load Area= 438.3 MW
Path 44-South of SONGS= 216.9 MW
SONGS South 368.0 MW
Talega North -254.8 MW

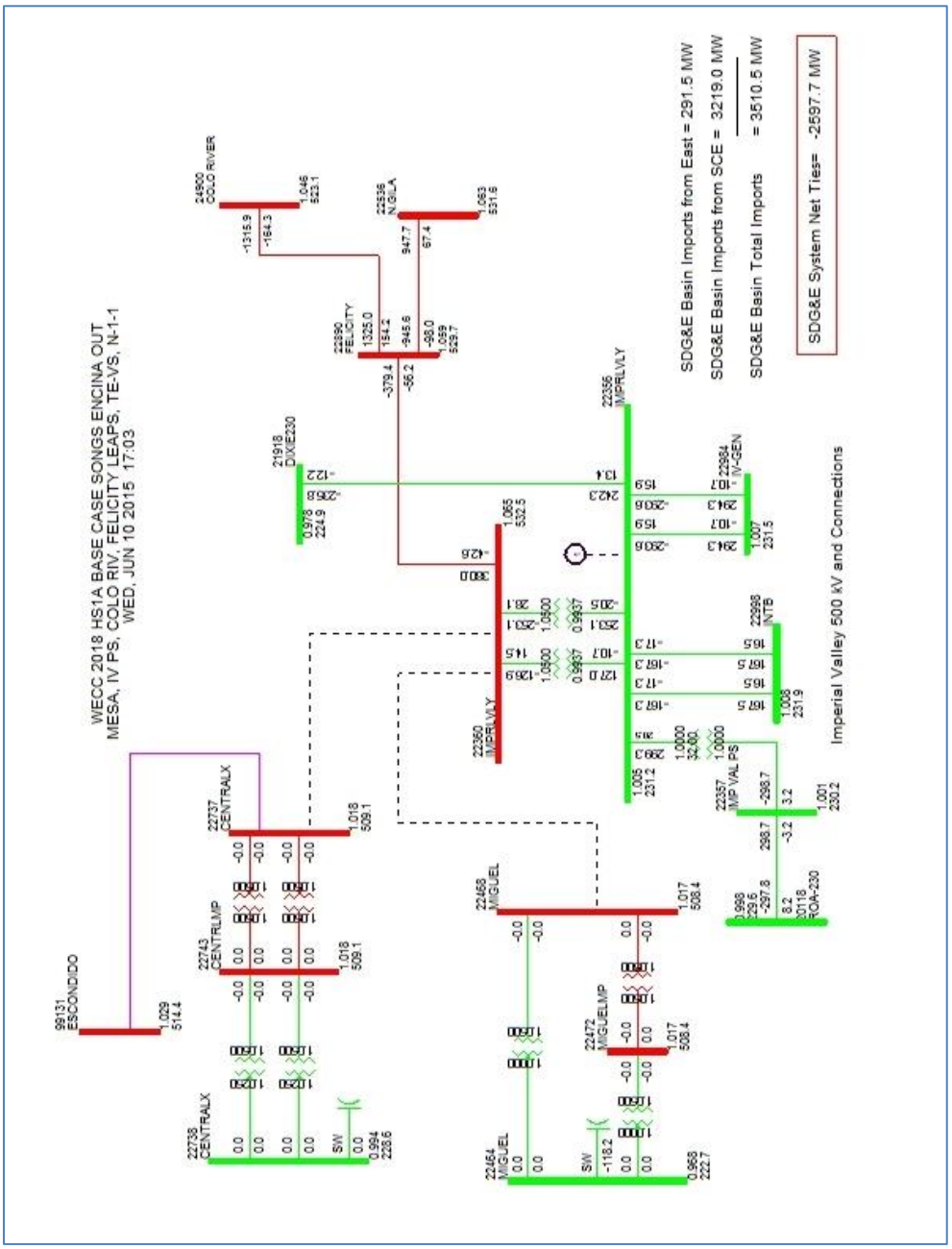

WECC 2018 HS1A BASE CASE SONGS ENCINA OUT
MESA, IV PS, COLO RIV, FELICITY LEAPS, TE-VS ADDED
WED, JUN 10 2015 15:28
South of Lugo Flows = 4105.0 MW
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: <=30.000 <=230.000 <=345.000 <=500.000 >500.000
24042 ELDORDO
24097 MOHAVE
24801 DEVERS
24151 VALLEYSC
24845 ALBERHILL
24800 COLO RIVER
15021 PALOVRDE
22390 FELICITY
99104 LEAPS
24154 VILLA PK
25201 LEWIS
22344 TALEGA
24025 CHINO
24137 SERRANO
24138 SERRANO
24236 RANCHVST
24092 MIRALOMA
24086 LUGO
24156 VINCENT
26105 VICTORVL

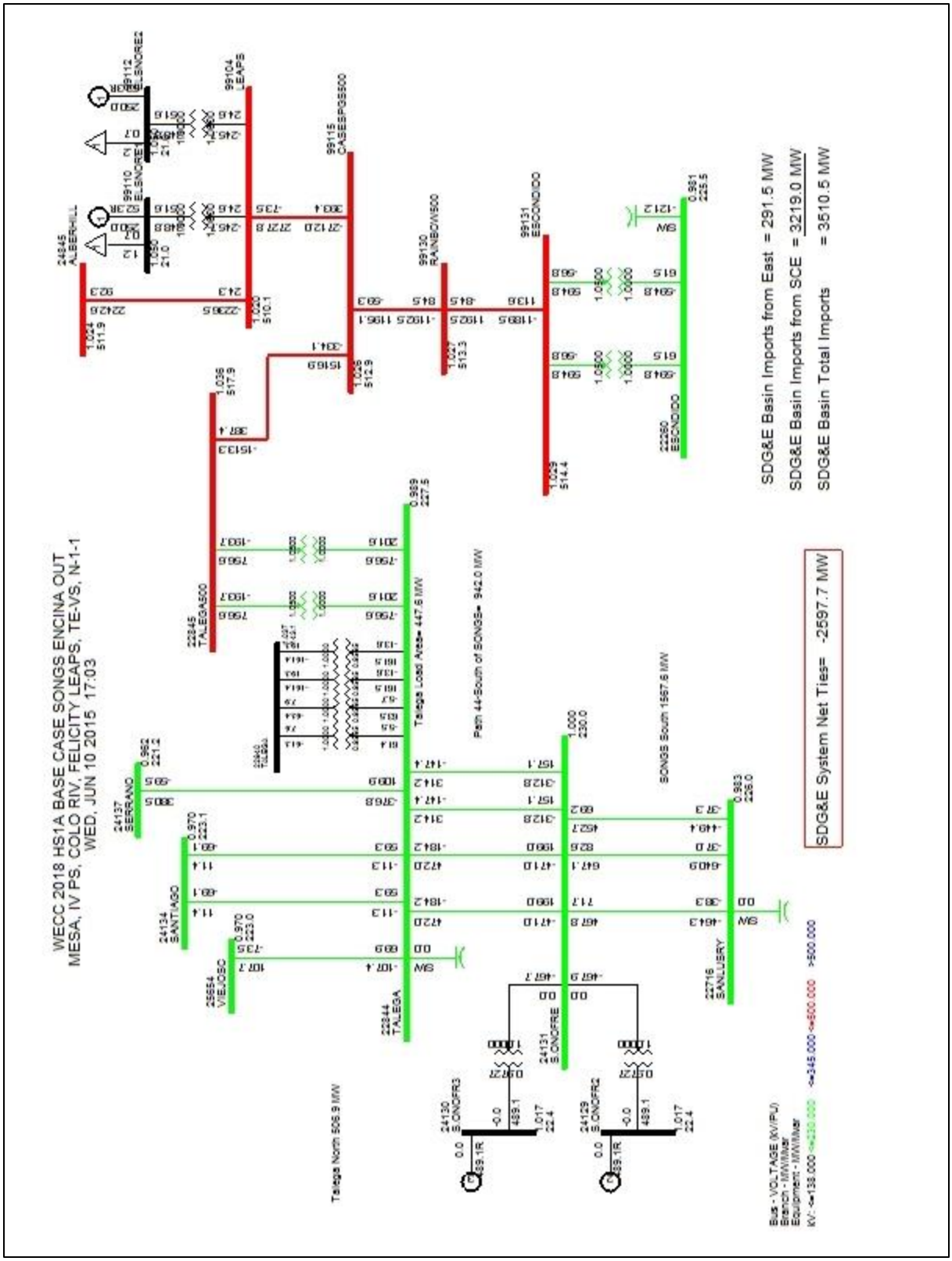
B. Power flow diagrams for 2018 system heavy load

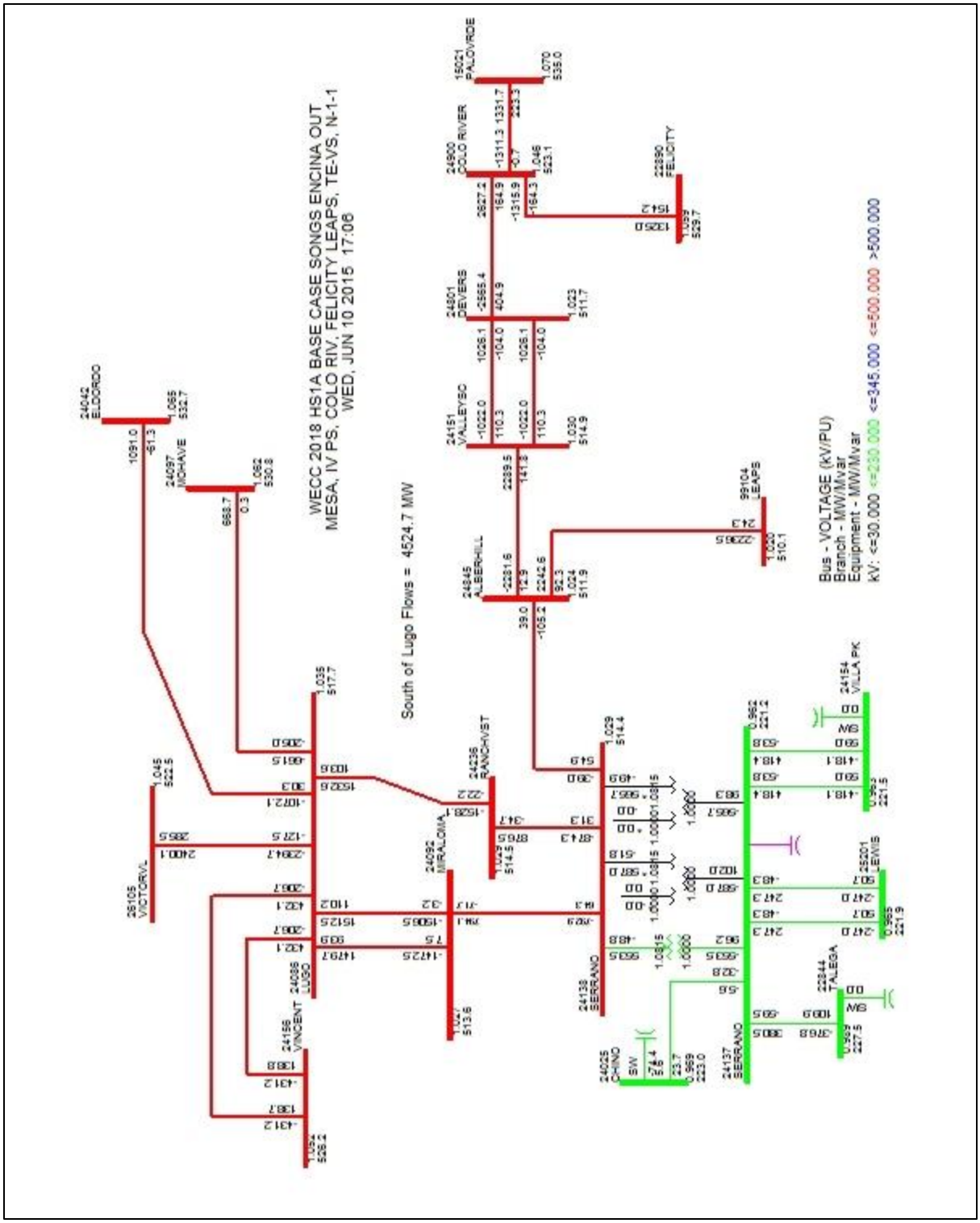
1. Under N-1-1 Contingency Conditions

a) Loss of Imperial Valley-Miguel 500 kV Line

b) Followed by Loss of Imperial Valley-Suncrest 500 kV Line)




WECC 2018 HS1A BASE CASE SONGS ENCINA OUT
MESA, IV PS, COLO RIV, FELICITY LEAPS, TE-VS, N-1-1
WED, JUN 10 2015 17:03
SDG&E Basin Imports from East = 291.6 MW
SDG&E Basin Imports from SCE = 3219.0 MW
SDG&E Basin Total Imports = 3510.5 MW
SDG&E System Net Ties= -2597.7 MW
Path 44-South of SONGS= 942.0 MW
Talega Loss Area= 447.6 MW
SONGS South 1567.6 MW
Talega Norm 506.9 MW
99112 ELSNORE2
99110 ELSNORE1
99104 LEAPS
99115 CASESPGS500
99130 RAINBOW500
99131 ESCNDIDO
24845 ALBERHILL
22360 ESCNDIDO
22845 TALEGA500
24137 SERRANO
24134 SANTIAGO
25654 VIEJOSC
22844 TALEGA
24131 S.ONOFRE
24130 S.ONOFR3
24129 S.ONOFR2
22716 SANLUISRY
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: <=138.000 <=230.000 <=345.000 <=500.000 >500.000


WECC 2018 HS1A BASE CASE SONGS ENCINA OUT
MESA, IV PS, COLO RIV, FELICITY LEAPS, TE-VS, N-1-1
WED, JUN 10 2015 17:06
South of Lugo Flows = 4524.7 MW
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: <=30.000 <=230.000 <=345.000 <=500.000 >500.000

C. Power flow diagrams for2018 system heavy load

1. Under System Normal Conditions, with the following projects added:

a) Mesa Cal 500/230 kV Substation

b) Colorado River Substation

c) Felicity Substation and Felicity-Colorado River 500 kV line

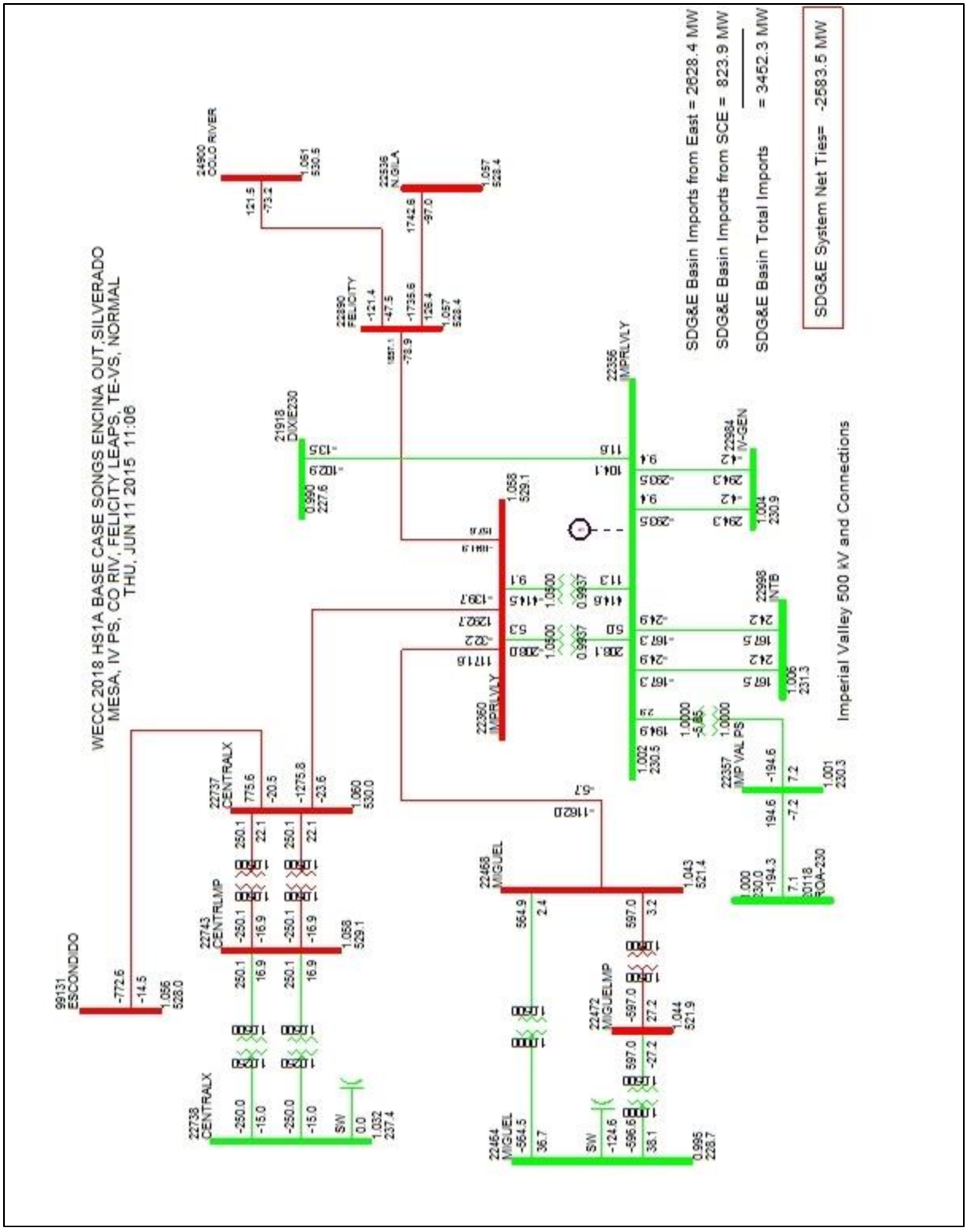
d) Imperial Valley-Rosarita 230 kV Line Phase Shifter

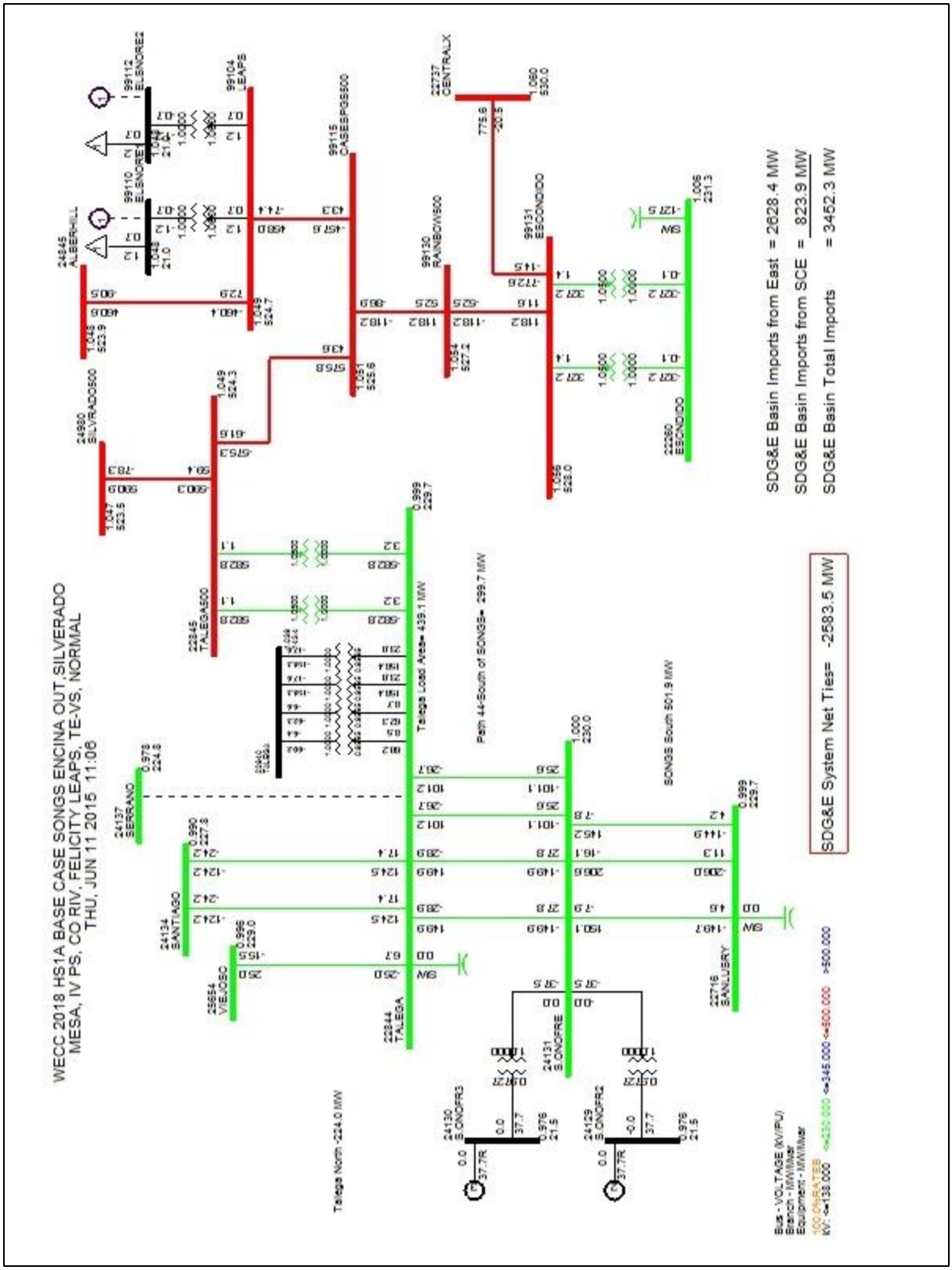
e) LEAPS

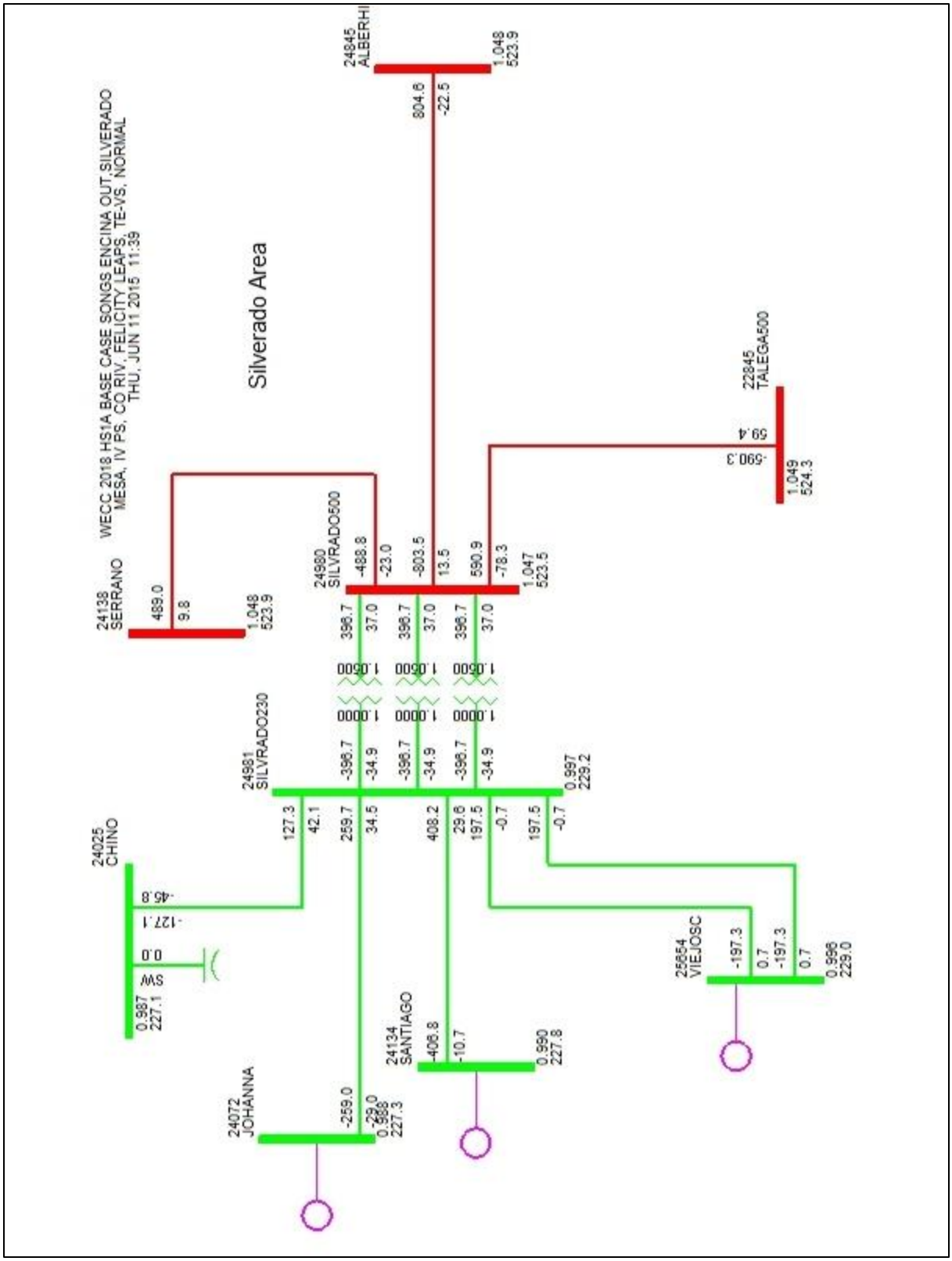
f) Enhanced TE-VS

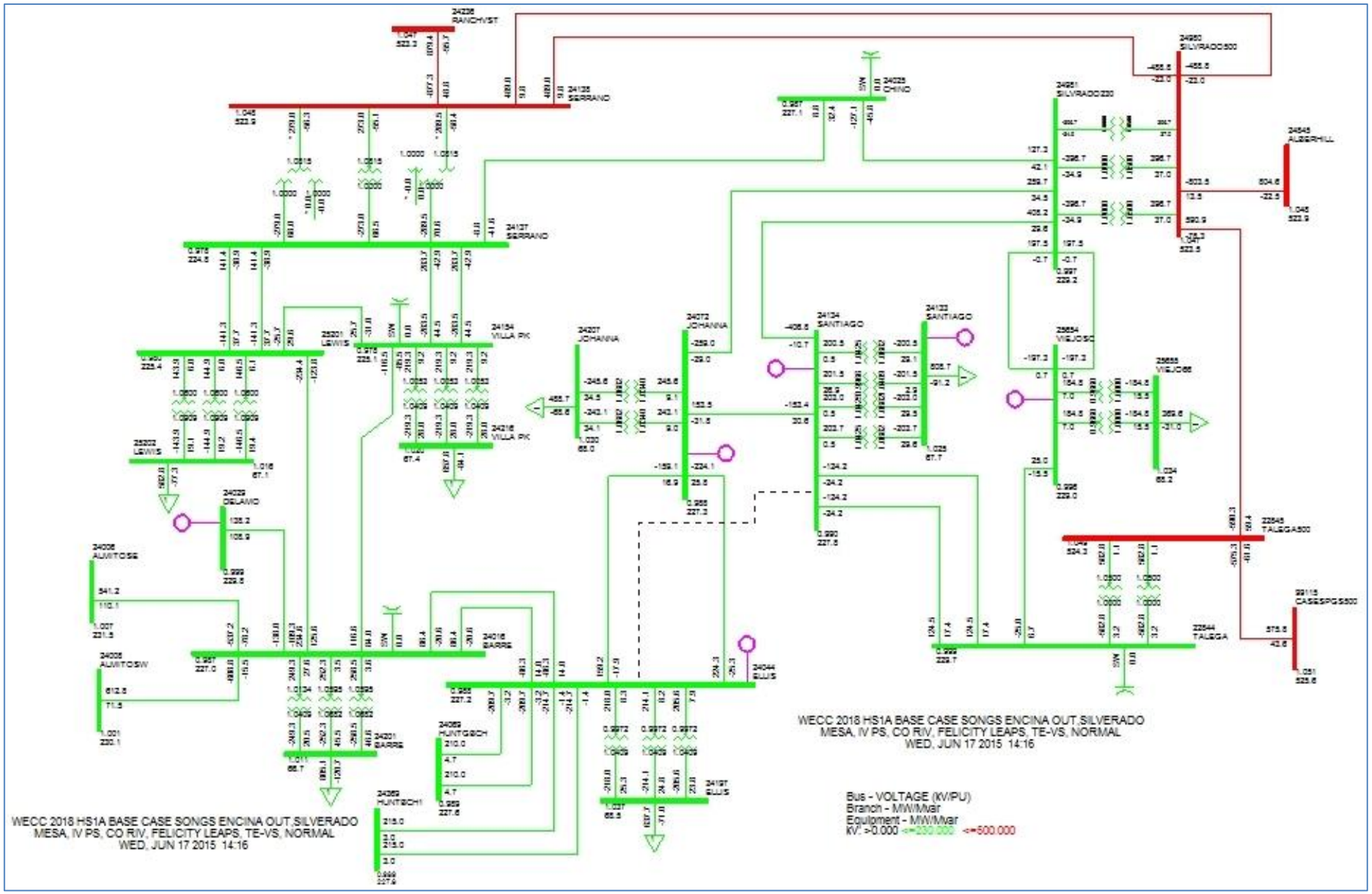
g) Suncrest-Escondido 500 kV Line

h) Silverado 500/230 kV Substation and 230 kV Upgrades


WECC 2018 HS1A BASE CASE SONGS ENCINA OUT,SILVERADO
MESA, IV PS, CO RIV, FELICITY LEAPS, TE-VS, NORMAL
THU, JUN 11 2015 11:06
SDG&E Basin Imports from East = 2628.4 MW
SDG&E Basin Imports from SCE = 823.9 MW
SDG&E Basin Total Imports = 3452.3 MW
SDG&E System Net Ties= -2583.5 MW
Imperial Valley 500 kV and Connections
24900 COLO RIVER
22536 N.GILA
22390 FELICITY
21918 DIXIE230
22356 IMPRLVLY
22984 IV-GEN
22998 INTB
22357 IMP VAL PS
30118 TOA-230
22360 IMPERLVLY
22737 CENTRALX
22743 CENTRLMP
22738 CENTRALX
99131 ESCONDIDO
22468 M/GUEL
22472 M/GUELMP
22464 M/GUEL
SW


WECC 2018 HS1A BASE CASE SONGS ENCINA OUT,SILVERADO
MESA, IV PS, CO RIV, FELICITY LEAPS, TE-VS, NORMAL
THU, JUN 11 2015 11:06
SDG&E Basin Imports from East = 2628.4 MW
SDG&E Basin Imports from SCE = 823.9 MW
SDG&E Basin Total Imports = 3452.3 MW
SDG&E System Net Ties= -2583.5 MW
Path 44-South of SONGS= 299.7 MW
Talega Load Area= 439.1 MW
SONGS South 501.9 MW
Talega North -224.0 MW
99112 ELSNORE2
99110 ELSNORE
99104 LEAPS
99115 CASESPGS500
22737 CENTRALX
99130 RAINBOW500
99131 ESCONDIDO
22360 ESCONDIDO
24845 ALBERHILL
24980 SILVRADO500
22845 TALEGA500
24137 SERRANO
24134 SANTIAGO
25654 VIEJOSC
22844 TALEGA
24131 SONGRE
24130 SONGRR3
24129 SONGRR2
22716 SANLUSRY
Bus - VOLTAGE (KV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
KV: <=138.000 <=230.000 <=345.000 <=500.000 >500.000


WECC 2018 HS1A BASE CASE SONGS ENCINA OUT,SILVERADO
MESA, IV PS, CO RIV, FELICITY LEAPS, TE-VS, NORMAL
THU, JUN 11 2015 11:39
Silverado Area
24845
ALBERHI
1.048
523.9
804.6
-22.5
22845
TALEGA500
59.4
-590.3
1.049
524.3
24138
SERRANO
469.0
9.8
1.048
523.9
24980
SILVRADO500
-488.8
-23.0
-803.5
13.5
590.9
-78.3
1.047
523.5
396.7
37.0
-396.7
-34.9
24981
SILVRADO230
0.997
229.2
127.3
42.1
259.7
34.5
408.2
29.6
197.5
-0.7
197.5
-0.7
24025
CHINO
-45.8
-127.1
0.0
SW
0.987
227.1
25854
VIEJOSC
-197.3
0.7
0.996
229.0
24134
SANTIAGO
-406.8
-10.7
0.990
227.8
24072
JOHANNA
-259.0
-29.0
227.3


WECC 2018 HS1A BASE CASE SONGS ENCINA OUT,SILVERADO
MESA, IV PS, CO R/V, FELICITY LEAPS, TE-VS, NORMAL
WED, JUN 17 2015 14:16
WECC 2018 HS1A BASE CASE SONGS ENCINA OUT,SILVERADO
MESA, IV PS, CO R/V, FELICITY LEAPS, TE-VS, NORMAL
WED, JUN 17 2015 14:16
Bus - VOLTAGE (kV/PU)
Branch - MW/Mvar
Equipment - MW/Mvar
kV: >0.000 <=230.000 <=500.000