

**Comparative Reliability Evaluation for  
Alternative New 500 kV Transmission Lines  
into San Diego**

**By**

**John Kyei  
Grid Planning Department  
California ISO**

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## **Executive Summary**

Studies conducted by the Southwest Transmission Expansion Plan (STEP) in 2003 indicate that a new 500 kV line into San Diego will be needed to serve future load growth. The final report of the San Diego Gas and Electric (SDG&E) 2003 grid assessment and transmission expansion plan re-enforces the need for an increase in San Diego's import capability, which is currently 2850 MW. This deficiency is primarily due to the inability to permit the Valley-Rainbow 500 kV line, the planned retirement of the South Bay generation units in 2009, and increasing load in San Diego.

STEP examined several options for routing a new line to San Diego. Several alternative transmission lines were considered from Imperial Valley into San Diego as well as the new 500 kV line associated with the Lake Elsinore Advanced Pumped Storage Project (LEAPS). High-level studies were conducted for all of these options.

This study evaluated the relative reliability benefits of the line associated with the LEAPS project and a new line from Imperial Valley into San Diego (Imperial Valley-San Diego Expansion Plan or ISEP). The reliability benefit of a combination of these two transmission projects was also evaluated.

The study results revealed the relative reliability benefits of both the ISEP and the LEAPS projects. Both projects can support a San Diego import level (all lines in service) of 3600 MW. Both projects would require additional facilities or upgrades to achieve this import limit.

However, there are differences in the operational flexibility that each option provides. The ISEP project will lead to the elimination of the existing SPS for the Imperial Valley-Miguel 500 kV outage, require less new voltage support additions and result in lower West of Devers and South of Lugo flows. On the other hand, the LEAPS project would support a higher import limit with a section of the Southwest Power Link (SWPL) out of service.

A combination of the ISEP and LEAPS projects provides additional benefits such as a 3800 MW import capability to San Diego.

## **1.0 Background**

Studies conducted by the Southwest Transmission Expansion Plan (STEP) in 2003 indicate that there will be a need for a new 500 kV line to San Diego to serve future load growth. The final report of the San Diego Gas and Electric (SDG&E) 2003 grid assessment and transmission expansion plan re-enforces the need for an increase in San Diego's import capability, which is currently 2850 MW. This deficiency is primarily due to the inability to permit the Valley-Rainbow 500 kV line, the planned retirement of the South Bay generation units in 2009, and increasing load in San Diego.

STEP examined several options for routing a new line to San Diego. Several alternative transmission lines were considered from Imperial Valley into San Diego as well as the new 500 kV line associated with the Lake Elsinore Advance Pumped Storage Project (LEAPS). High-level studies were conducted for all of these options.

This study provides an objective reliability assessment for the line associated with the LEAPS project and the most technically desirable alternative for a new line from Imperial Valley into San Diego. The study also examines the reliability benefits of a combination of these two transmission projects.

## **2.0 Study objective and scope**

The main objective of the study is to evaluate the relative reliability benefits of the following transmission options:

- Imperial Valley-Ramona 500 kV line (Imperial Valley –San Diego Expansion Plan)
- Talega-Escondido-Valley/Serrano 500 kV line (without the 500 MW Lake Elsinore Advanced Pumped Storage project)
- Both of the above projects combined and connected to the same substation in San Diego.

The report documents the impact (if any) of the transmission options evaluated on the California ISO controlled grid and the WECC system in general. Additionally, the report provides the maximum San Diego Import level for each of the transmission options evaluated and the facility upgrades required to accommodate the maximum import. The report provides a summary of the relative reliability benefits of each of the routing options.

Also included in the report is the sensitivity studies conducted for the Talega-Escondido-Valley/Serrano 500 kV line with the LEAPS 500 MW Pumped Storage project.

Finally, the report compares the reliability benefits of connecting Otay Mesa generation through Old Town and Sycamore Canyon with an alternate connection through South Bay and Sycamore Canyon for each of the routing options studied.

### **3.0 Study description**

#### **Base case development**

The WECC 2007 and 2013 heavy summer cases were used as the starting cases for the study. The 2007 heavy summer case modeled San Diego area peak load and losses at 4720 MW and the 2013 case has the peak load and losses at 5400 MW. Two sets of cases were developed from the 2013 summer peak case. These cases modeled:

- 1 in 10 load with all facilities in service for thermal and post-transient studies
- 1 in 10 load and SWPL out of service for N-1-1 studies.

The pre-project base cases modeled:

- 1) Palomar (541 MW)
- 2) South Bay generation in the 2007 base case but not in the 2013 case.
- 3) Otay Mesa (596 MW) connected to San Diego through two new 230 kV lines. One of the lines would connect to Old Town or South Bay and one would connect to Sycamore Canyon. The Otay Mesa - South Bay connection is used as sensitivity in the 2013 base case.
- 4) All proposed projects that are in phase 2 or 3 of the WECC rating process and are expected to be in service prior to summer of 2007.
- 5) Net Interchange with CFE at 0 MW (the sum of imperial Valley and Tijuana flows).
- 6) SDG&E imports at 2850 MW

#### **Study methodology**

The pre-project cases were tested to ensure compliance with the California ISO Grid Planning Standards, which incorporate the NERC/WECC Planning Standards. Initial screening was performed on the pre-project cases to determine if higher San Diego imports are feasible. Transfers into San Diego were increased until limits were reached for the post-project cases. The critical contingencies and the associated transfer levels were identified. These formed the basis for identifying the transfer increases for the various routing options.

To accommodate the increase in imports, the following order for generation reductions were used:

- 1) South Bay generation
- 2) Encina generation
- 3) San Diego area peaking units
- 4) Pro-rata reductions at Otay and Palomar

The following methodology was adhered to:

- **Power Flow Study**

No system element is loaded above its normal continuous thermal rating under pre-contingency conditions or with a single generator out, or above its emergency rating under contingency conditions.

- **Post transient**

The maximum voltage deviations allowed at all buses under contingency conditions in the post-transient time frame are 5% and 10% for N-1 and N-2 contingencies, respectively, unless a lower standard has been previously adopted for specific buses.

All outages were studied using governor power flow tools. Remedial actions for each outage were modeled according to the 2004 Operating Studies Subcommittee (OSS) Handbook. All system automatic actions such as insertion or bypassing of shunt and series capacitors are modeled as appropriate.

## 4.0 Study Results

### Pre-project Case Screening and San Diego Maximum Imports

The pre-project cases were tested to determine whether a higher import capability into San Diego is achievable. This will help in evaluating the incremental benefits in import due to the projects.

- a) 2850 MW San Diego Import (2007) with South Bay available for dispatch
- 1) Critical contingency: Imperial Valley – Miguel 500 kV line with SPS to trip IV generation
  - 2) Limiting facility: Imperial Valley- La Rosita 230 kV line
  - 3) Voltage support required: None
  - 4) System improvements required: None
  - 5) G-1/N-1 criteria: Satisfied
  - 6) Other comments: Voltage support at Devers would be necessary to increase maximum San Diego import beyond 2850 in 2007.

Figure 1 depicts the power flow map (all lines in service) for the major 500 and 230 kV lines in the San Diego Area for the above pre-project case.

- b) 2850 MW San Diego Import (2007) with South Bay retired
- 1) Critical contingency: Imperial Valley – Miguel 500 kV line with SPS to trip IV generation
  - 2) Limiting facility: Imperial Valley- La Rosita 230 kV line
  - 3) Voltage support required: ~250 Mvar at South Bay
  - 4) System improvements required:
    - Re-conductor B – Kettner 69 kV line (112%)
    - Re-conductor Kettner – Old Town 69 kV line (103%)
    - Re-conductor Carlton Hills tap – Sycamore 138 kV line (106%)
    - Install SPS to trip load for Miguel - Mission #1&2 230 kV outage. The outage of the Miguel – Mission #1&2 230 kV lines overloads Miguel 230/138 kV transformer by 6%.

Note: SDG&E has a plan to re-conductor Carlton Hills tap – Sycamore 138 kV line in 2006 in association with the Otay Mesa Generation project.
  - 5) G-1/N-1 criteria: Satisfied
  - 6) Other comments: Imports beyond 2850 MW without South Bay generation will lead to overloading on the Old Town 230/69 kV transformers under an N-1 contingency (i.e. an Outage of Old Town #1 230/69 kV transformer overloads the Old Town #2 230/69 kV transformer and vice versa)

Figure 2 shows the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 2850 MW import into San Diego in 2007 with South Bay retired.

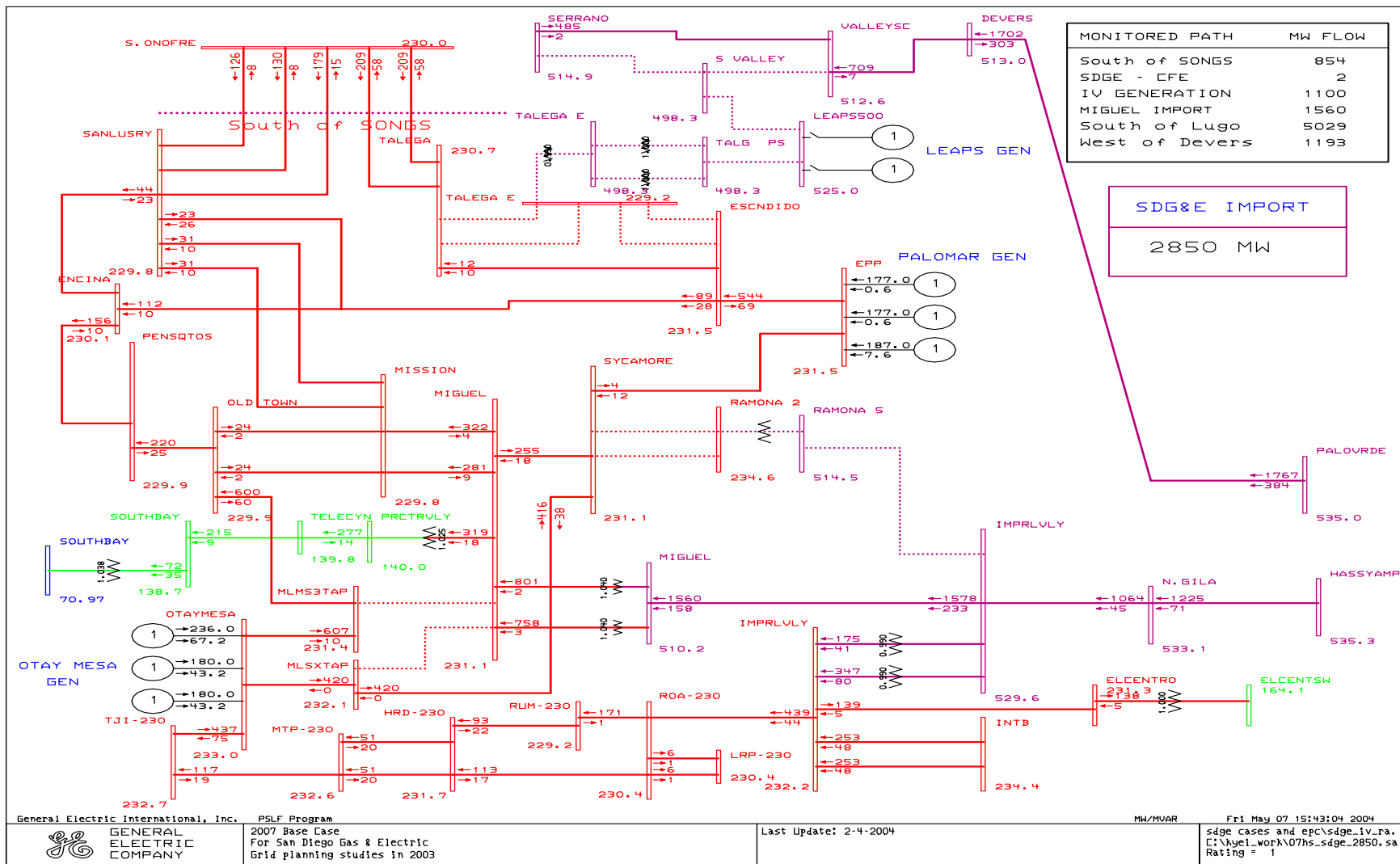


Figure 1: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, 2007 pre-project case (2850 MW San Diego import with South Bay generation available for dispatch)

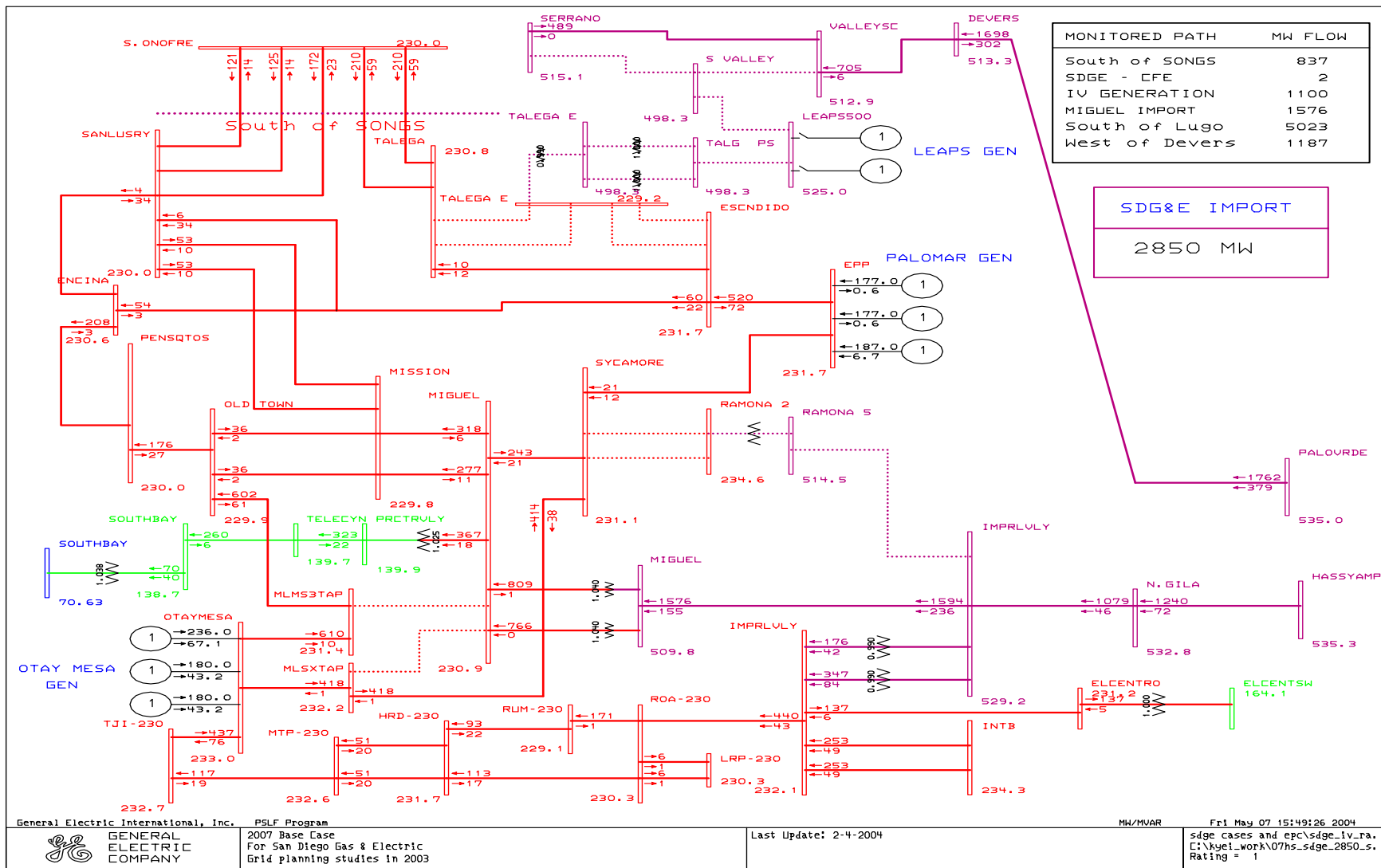


Figure 2: Power Flow Map depicting major 500 and 230 kV transmission lines in San Diego Area, 2007 pre-project case (2850 MW San Diego import with South Bay retired)

c) 3100 MW San Diego Import (2007) with South Bay available for dispatch

- 1) Critical contingency: Old Town #1 or #2 230/69 kV transformer outage
- 2) Limiting facility: Old Town #1 or #2 230/69 kV transformer
- 3) Voltage support required: ~400 Mvar required at Devers
- 4) System improvements required:
  - Re-conductor B – Kettner 69 kV line (115%)
  - Re-conductor Kettner – Old Town 69 kV line (106%)
  - Re-conductor NAVSTMTR-Division 69 kV line (126%)
  - Re-conductor Mira Sorrento – Penasquitos 138 kV line (109%)
- 5) G-1/N-1 criteria: Satisfied
- 6) Other comments: Penasquitos #2 230/69 kV transformer is another limiting facility (due to an outage of Penasquitos #1 230/69 kV transformer).

Figure 3 shows the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 3100 MW import in 2007 with South Bay available for dispatch.

d) 2850 MW San Diego Import (2013) with South Bay retired

- 1) Critical contingency: Old Town #1 or #2 230/69 kV transformer outage
- 2) Limiting facility: Old Town #1 or #2 230/69 kV transformer
- 3) Voltage support required: ~250 Mvar required at South Bay
- 4) System improvements required:
  - Re-conductor B – Kettner 69 kV line (120%)
  - Re-conductor Kettner – Old Town 69 kV line (111%)
  - Re-conductor Rincon-Warners 69 kV line (103%)
  - Re-conductor Sycamore-Carlton Hills Tap 138 kV line (116%)
  - Replace Old Town #1 & 2 230/69 kV transformer (110%)
  - Replace Sycamore #1& 2 230/69 kV transformer (103%)
  - Install SPS to trip load for Miguel-Mission #1&2 230 kV outage. The outage of the Miguel – Mission #1&2 230 kV lines overloads Miguel 230/138 kV transformer by 10%.
- 5) G-1/N-1 criteria: Not satisfied. Not enough San Diego internal resources without Otay Mesa online. This calls for an increase in San Diego import capability before 2013.
- 6) Other comments: Import beyond 2850 MW will not be possible without new facilities since the Miguel 230/138 kV transformer is loaded at 100% of its normal rating.

Figure 4 depicts the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 2850 MW import in 2013 with South Bay retired.



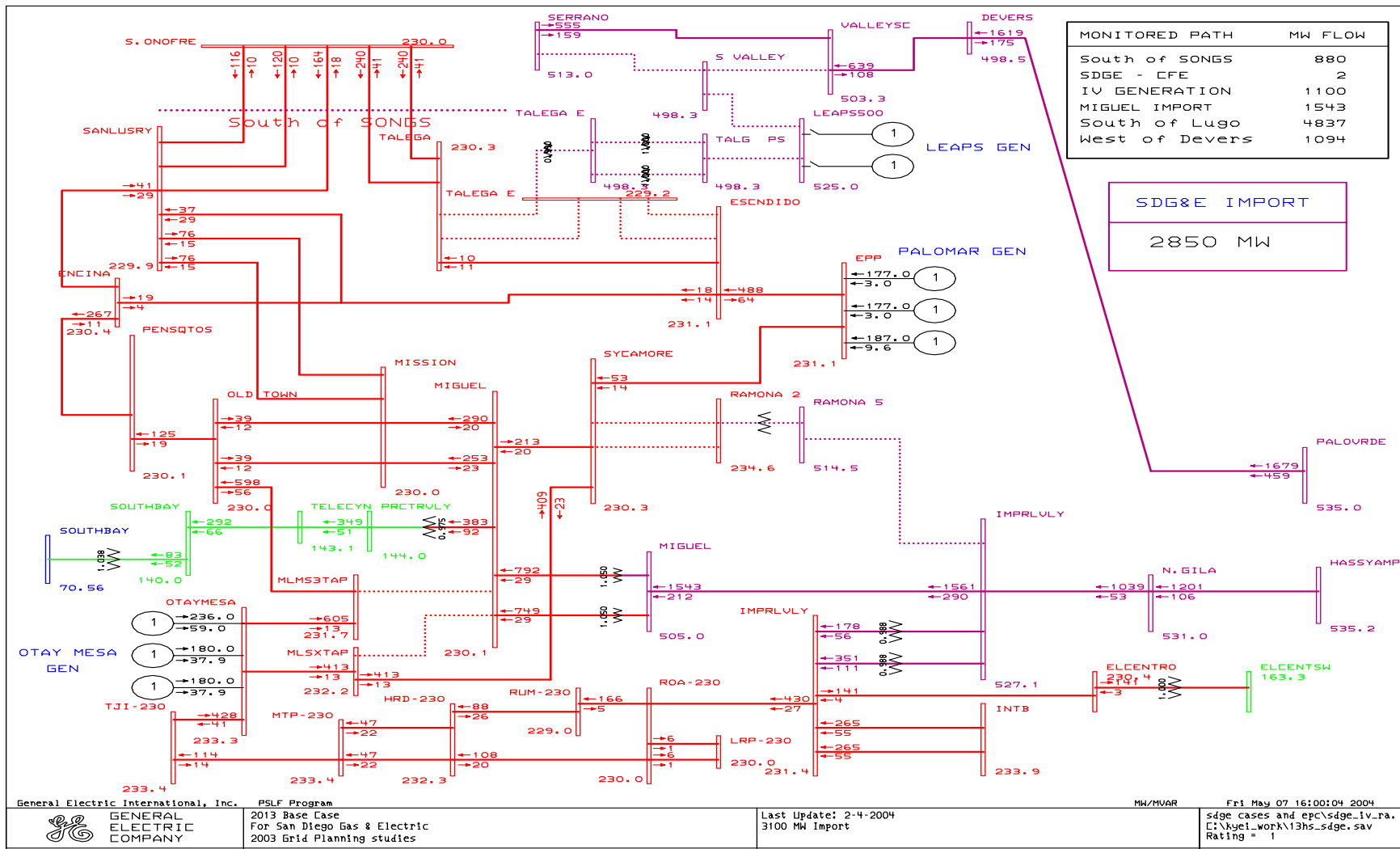


Figure 4: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, 2013 pre-project case (2850 MW San Diego import with South Bay retired)

## Post project case and San Diego Maximum Import

### a) Imperial Valley –Ramona 500 kV line (ISEP project)

The project composition as depicted in Figure 5 is:

- ✓ New Imperial Valley-Ramona 500 kV line
- ✓ Two new Ramona-Sycamore 230 kV lines
- ✓ New 500/230 kV transformer at Ramona

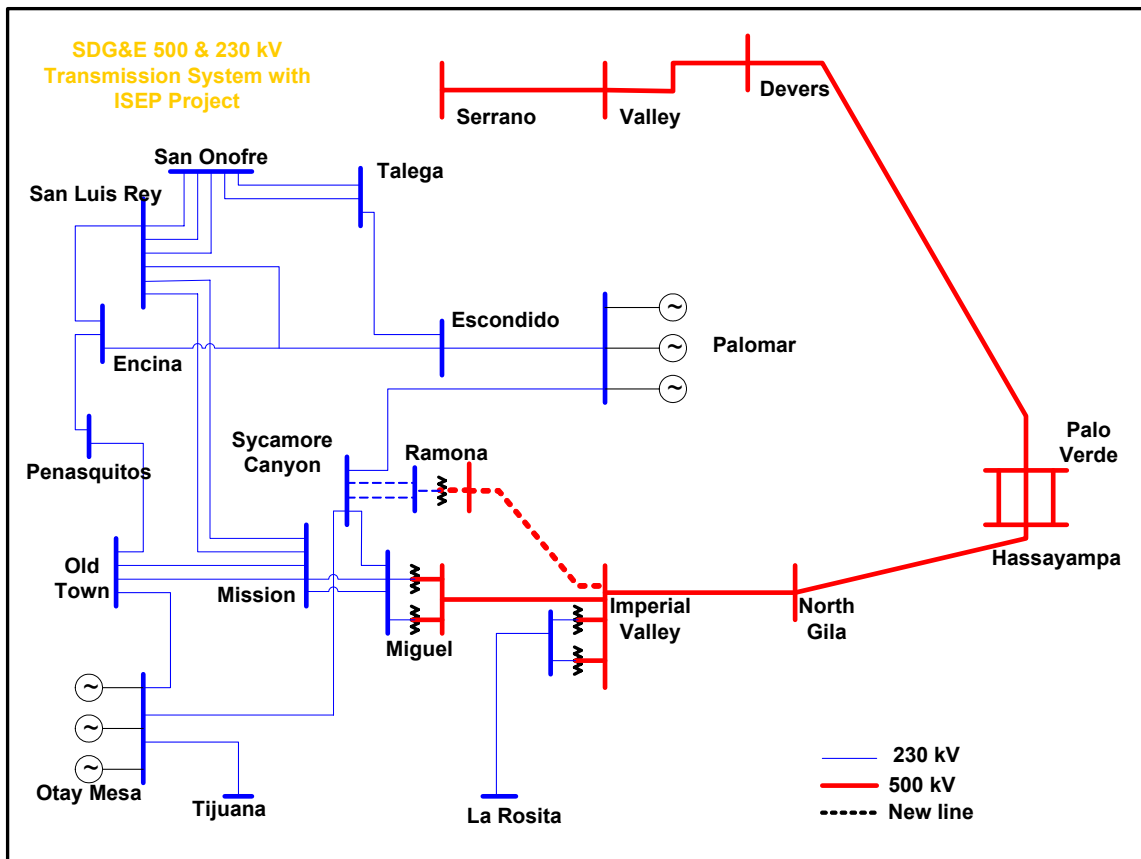


Figure 5: SDG&E 500 and 230 kV Transmission System with ISEP Project

- 1) ISEP project without additional facility
  - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
  - Maximum import with ISEP project: 2550 MW
  - Limiting Facility: Sycamore #1 & 2 230/69 kV transformers (100% normal rating)
  
- 2) ISEP project with a new Sycamore-Penasquitos 230 kV line
  - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
  - Maximum import: 3000 MW

- Limiting Facility: Sycamore #1 & 2 230/69 kV transformers (100% normal rating)
- 3) ISEP project with a new Sycamore-Penasquitos 230 kV line and a new Sycamore 230/69 kV transformer
- Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
  - Maximum import: 3350 MW
  - Limiting Facility: Penasquitos #2 230/69 kV transformers (100% normal rating)
- 4) ISEP project with a new Sycamore-Penasquitos 230 kV line, a new Sycamore 230/69 kV transformer and a new Penasquitos 230/69kV transformer
- Starting Case: 2850 MW San Diego Import (2013)
  - Maximum import: 3600 MW
  - Critical Contingency: Hassyampa-N. Gila 500 kV line
  - Limiting Facility: Miguel 230/138 kV transformers (100% normal rating)
  - Voltage Support required: ~300 MVAR at South Bay
  - System improvements required:
    - i) Replace Old Town #1 & 2 230/69 kV transformers (113%) or add a third 230/69 kV bank
    - ii) Re-conductor Pomerado-Poway 69 kV line (102% Normal rating)
    - iii) Re-conductor Scripps-Sycamore 69 kV line (110% Normal rating)
    - iv) Re-conductor Kettner-B 69 kV line (124%)
    - v) Re-conductor Old Town-Kettner 69 kV line (115%)
    - vi) Re-conductor Sycamore-Elliot 69 kV line (139%)
    - vii) Re-conductor Sycamore-Carlton Hills Tap 138 kV line (136%)
    - viii) Re-conductor NAVSTMTR-Division 69 kV line (101%)
    - ix) Install SPS to trip load for Miguel - Mission #1&2 230 kV outage. The outage of the Miguel – Mission #1&2 230 kV lines overloads Miguel 230/138 kV transformer by 4%
  - G-1/N-1 criteria: Satisfied
  - Other comments: No SPS is needed for IV-Miguel 500 kV line outage.

Figure 6 depicts the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 3600 MW import in 2013 with the ISEP project.

- 5) ISEP project with a new Sycamore-Penasquitos 230 kV line (2007 time frame)
- Starting Case: 3100 MW San Diego Import (2007) with South Bay available for dispatch
  - Maximum import: 3600 MW

- Critical Contingency: Hassyampa-N. Gila 500 kV line
- Voltage Support required: ~300 MVAR at South Bay
- System improvements required:
  - i) Replace Old Town #1 &2 230/69 kV transformers (113%) or add a third 230/69 kV bank
  - ii) Re-conductor Kettner-B 69 kV line (130%)
  - iii) Re-conductor Old Town-Kettner 69 kV line (118%)
  - iv) Re-conductor Sycamore-Elliot 69 kV line (139%)
  - v) Re-conductor Sycamore-Carlton Hills Tap 138 kV line (137%)
  - vi) Re-conductor NAVSTMTR-Division 69 kV line (101%)
- G-1/N-1 criteria: Satisfied
- Other comments: Only the new Penasquitos line may be needed in the 2007 time frame because of load level. About 200 MW of pro-rata reductions were applied to Otay Mesa and Palomar. The reductions on Otay Mesa and Palomar lessened the stress on the Sycamore transformers.

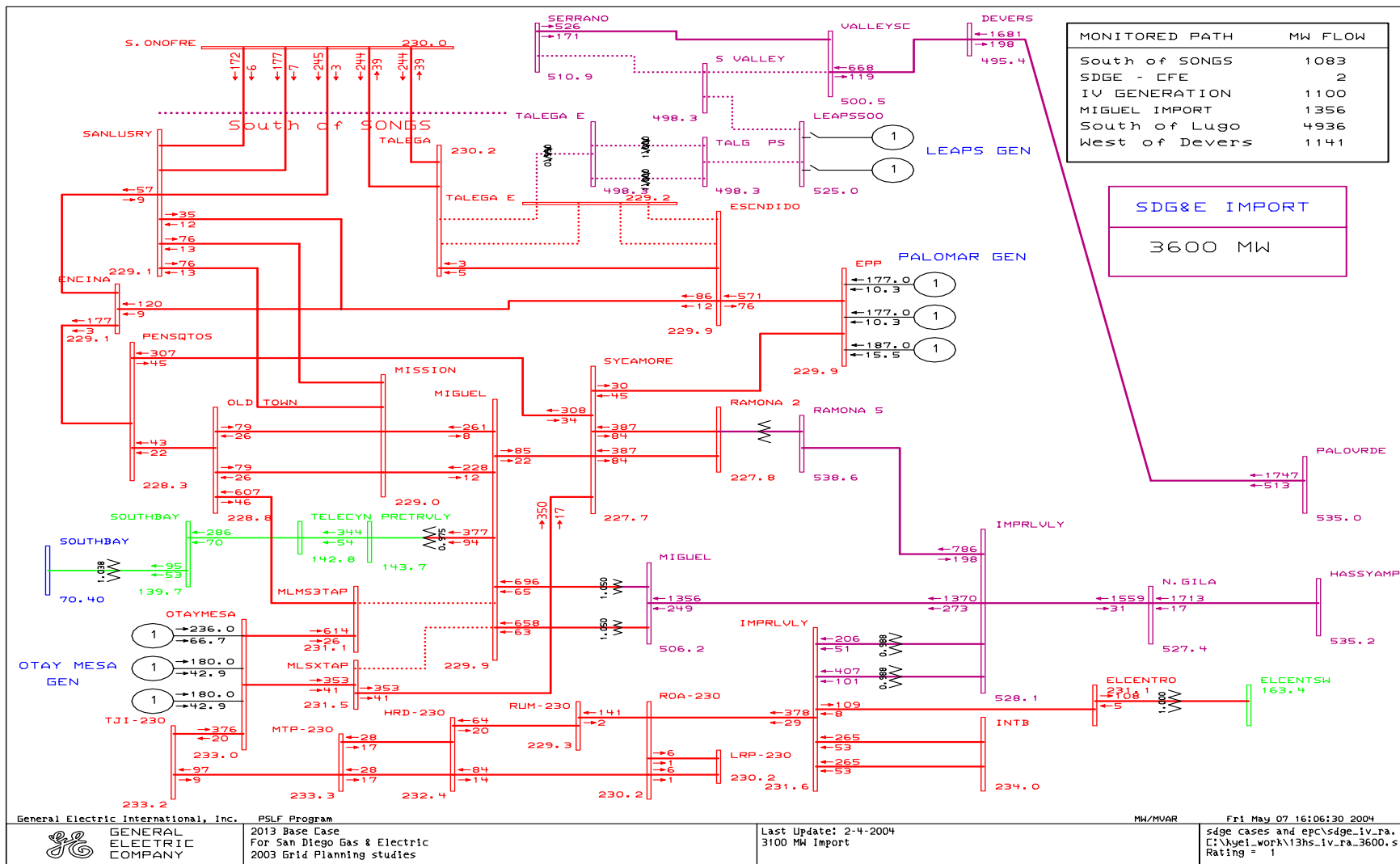


Figure 6: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, 2013 case with the ISEP project (3600 MW San Diego import)

b) Talega/Escondido-Valley/Serrano 500 kV line (LEAPS project without the 500 MW pump scheme)

The LEAPS project as shown in Figure 7 consist of:

- ✓ New Talega/Escondido- Valley/Serrano 500 kV line
- ✓ New Talega-Escondido 230 kV line that Loops into Talega/Escondido 500 kV substation
- ✓ Looping of the existing Talega-Escondido 230 kV line into the Talega/ Escondido 500 kV substation
- ✓ 500 kV Phase shifting transformer at Talega/Escondido 500 kV substation
- ✓ New 500/230 kV transformer at Talega/Escondido

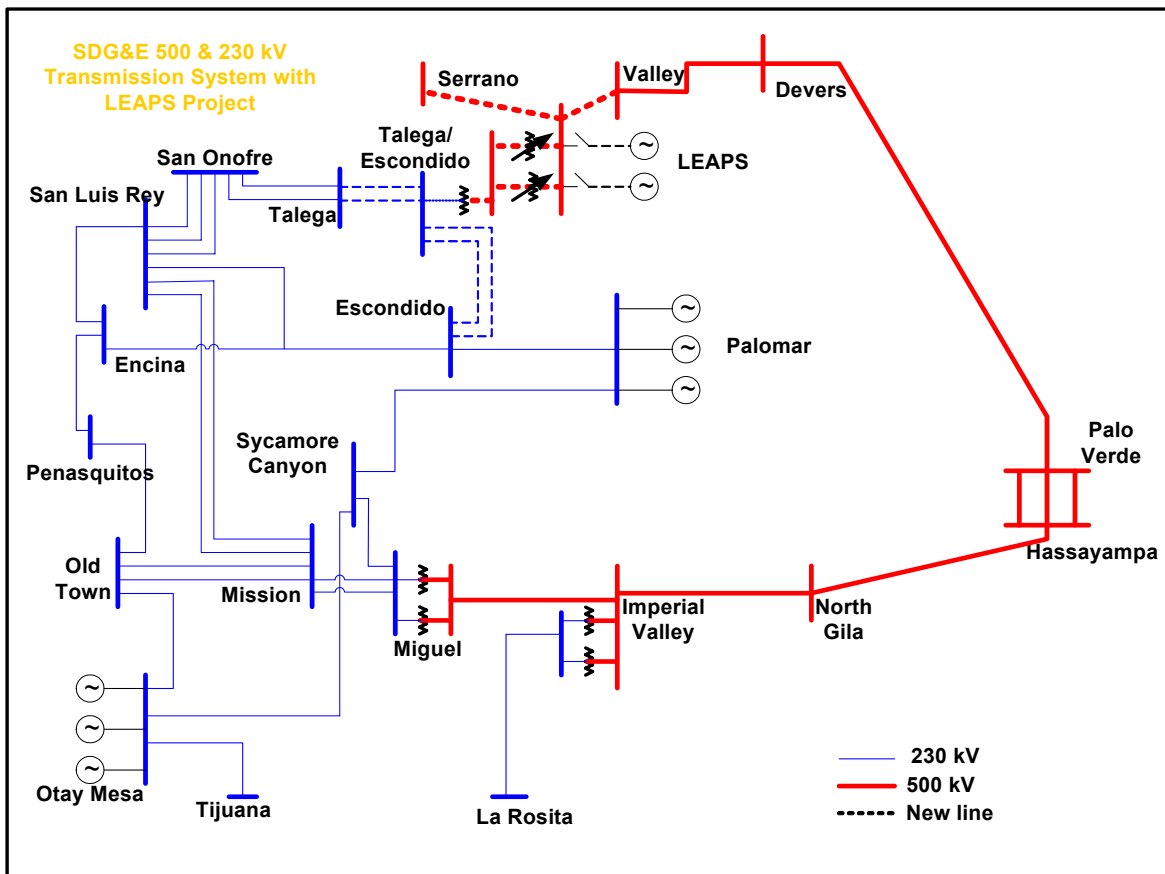


Figure 7: SDG&E 500 and 230 kV Transmission System with LEAPS Project

- 1) LEAPS project without any additional facility
  - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
  - Maximum import: 3050 MW
  - Limiting Facility: Miguel 230/138 kV transformer (100% normal rating)

- 2) LEAPS project with a new Miguel 230/138 kV transformer
- Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
  - Maximum import: 3600 MW
  - Critical Contingency: Imperial Valley – Miguel 500 kV line
  - Limiting Facility: Mission 230/69 kV transformer (100% normal rating)
  - Voltage support required: ~350 MVAR at South Bay and ~400 MVAR at Devers
  - System improvements required:
    - i) Replace Old Town #1 & 2 230/69 kV transformers (113%) or add a third 230/69 kV bank
    - ii) Replace Penasquitos #2 230/69 kV transformer (109%) or add a new 230/69 kV bank
    - iii) Replace Sycamore #1 & 2 230/69 kV transformers (110%) or add a third 230/69 kV bank
    - iv) Re-conductor Scripps - Sycamore 69 kV line (106% Normal rating)
    - v) Re-conductor Kettner - B 69 kV line (129%)
    - vi) Re-conductor Old Town - Kettner 69 kV line (118%)
    - vii) Re-conductor Miguel - Proctor Valley 138 kV line (105%)
    - viii) Re-conductor Sycamore - Carlton Hills Tap 138 kV line (119%)
    - ix) Re-conductor Rincon - Warners 69 kV line (107%)
    - x) Re-conductor South Bay - Telegraph Canyon 138 kV line (103%)
  - G-1/N-1 criteria: Satisfied
  - Other comments: None

Figure 8 depicts the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 3600 MW import in 2013 for the LEAPS project.

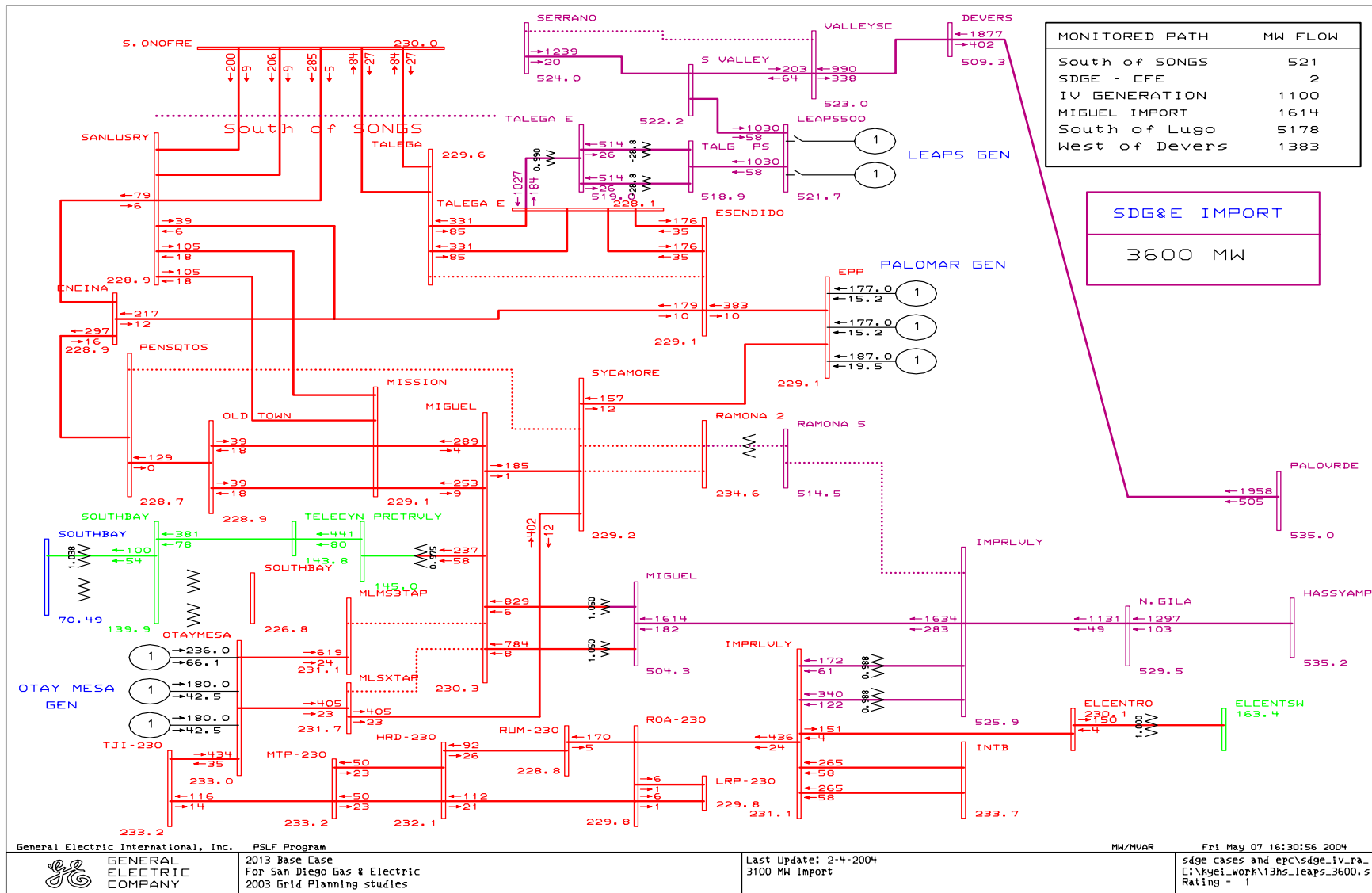


Figure 8: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, 2013 case with the LEAPS project (3600 MW San Diego import)

- LEAPS project with a new Miguel 230/138 kV transformer (2007 time frame)
  - Starting Case: 3100 MW San Diego Import (2007) with South Bay available for dispatch
  - Maximum import: 3600 MW
  - Critical Contingency: Imperial Valley – Miguel 500 kV line
  - Voltage support required: ~400 MVAR at South Bay and ~400 MVAR at Devers
  - System improvements required:
    - i) Replace Old Town #1 & 2 230/69 kV transformers (107%) or add a third 230/69 kV bank
    - ii) Replace Penasquitos #2 230/69 kV transformer (103%) or add a new 230/69 kV bank
    - iii) Replace Sycamore #1 & 2 230/69 kV transformers (102%) or add a third 230/69 kV bank
    - iv) Re-conductor Kettner - B 69 kV line (133%)
    - v) Re-conductor Old Town - Kettner 69 kV line (121%)
    - vi) Re-conductor NAVSTMTR - Division 69 kV line (140%)
    - vii) Re-conductor Miguel - Proctor Valley 138 kV line (105%)
    - viii) Re-conductor Sycamore - Carlton Hills Tap 138 kV line (116%)
    - ix) Install SPS to trip load for Miguel - Mission #1&2 230 kV outage. The outage of the Miguel – Mission #1&2 230 kV lines overloads:
      - ✓ Miguel – Proctor Valley 138 kV line by 23%
      - ✓ South Bay -Telegraph Canyon 138 kV line by 16%
      - ✓ Proctor Valley-Telegraph Canyon 138 kV line by 15%
  - G-1/N-1 criteria: Satisfied
  - Other comments: None
- c) LEAPS and ISEP Projects link with new Talega/Escondido-Ramona 500 kV line
- 1) LEAPS, ISEP, a new Talega/Escondido- Ramona 500 kV line without any additional facility as shown in Figure 9.
    - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
    - Maximum import: 3400 MW
    - Limiting Facility: Sycamore 230/69 kV transformer (100% normal rating)

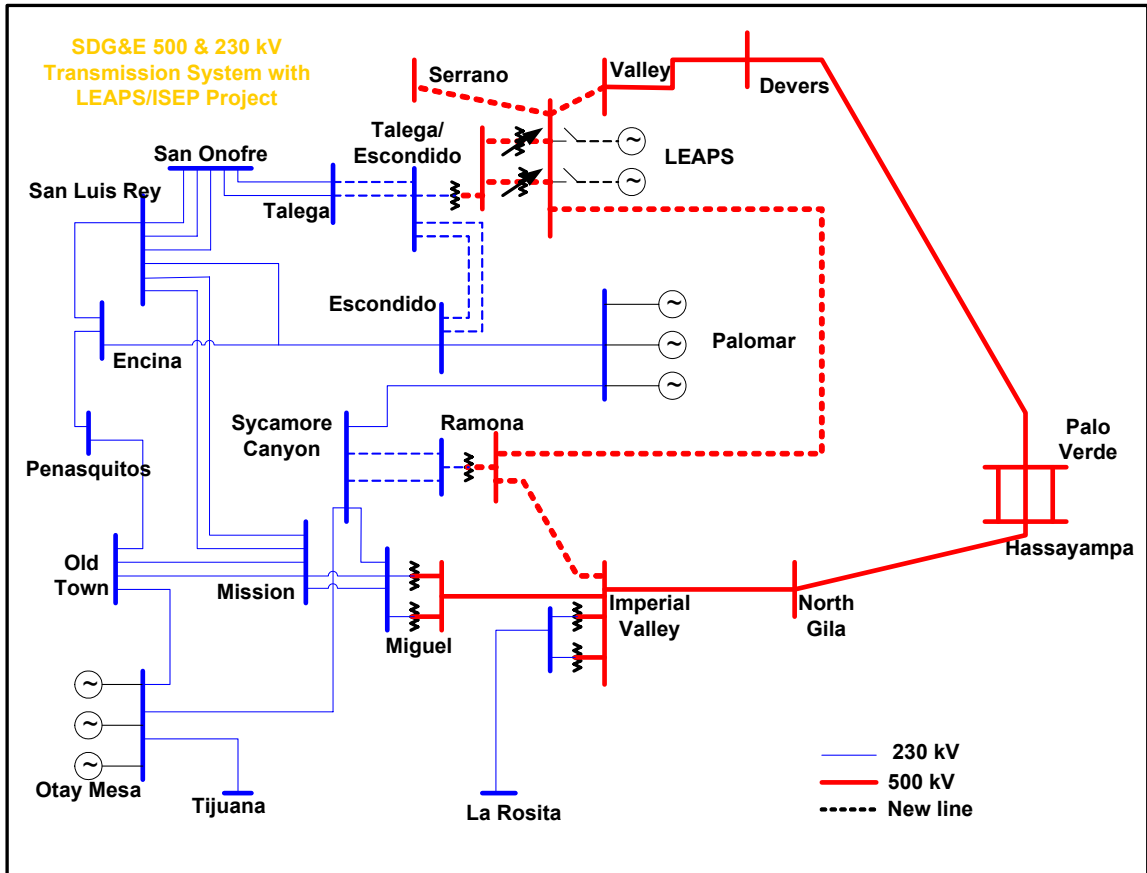


Figure 9: SDG&E 500 and 230 kV Transmission System with LEAPS and ISEP Projects linked through a new Talega/Escondido- Ramona 500 kV line

- 2) LEAPS, ISEP, a new Talega/Escondido-Ramona 500 kV line and a new Sycamore 230 /69 kV transformer
  - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
  - Maximum import: 3800 MW
  - Critical contingency: Hassayampa- N. Gila 500 kV line
  - Limiting Facility: Mission 230/69 kV transformer (100% normal rating), and Miguel 230/138 kV transformer (99% normal rating)
  - Voltage support required: ~350 MVAR at South Bay and ~400 MVAR at Devers
  - System improvements required:
    - i) Replace Old Town #1 & 2 230/69 kV transformers (120%) or add a third 230/69 kV bank
    - ii) Replace Penasquitos #2 230/69 kV transformer (109%) or add a new 230/69 kV bank
    - iii) Re-conductor Scripps - Sycamore 69 kV line (129% Normal rating)
    - iv) Re-conductor Elliot - Sycamore 69 kV line (109% Normal rating)
    - v) Re-conductor Kettner - B 69 kV line (133%)
    - vi) Re-conductor Old Town - Kettner 69 kV line (123%)

- vii) Re-conductor Elliot - Sycamore 69 kV line (152%)
  - viii) Re-conductor Sycamore - Chicarita 138 kV line (111%)
  - ix) Re-conductor Sycamore - Carlton Hills Tap 138 kV line (146%)
  - x) Re-conductor NAVSTMTR - Division 69 kV line (132%)
  - xi) Re-conductor Scripps - Sycamore 69 kV line (103%)
  - xii) Install SPS to trip load for Miguel - Mission #1&2 230 kV outage. The outage of the Miguel – Mission #1&2 230 kV lines overloads Miguel 230/138 kV transformer by 2%
- G-1/N-1 criteria: Satisfied
  - Other comments: None

Figure 10 depicts the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 3800 MW import in 2013 with the combined LEAPS and ISEP projects linked through a new Talega/Escondido-Ramona 500 kV line.

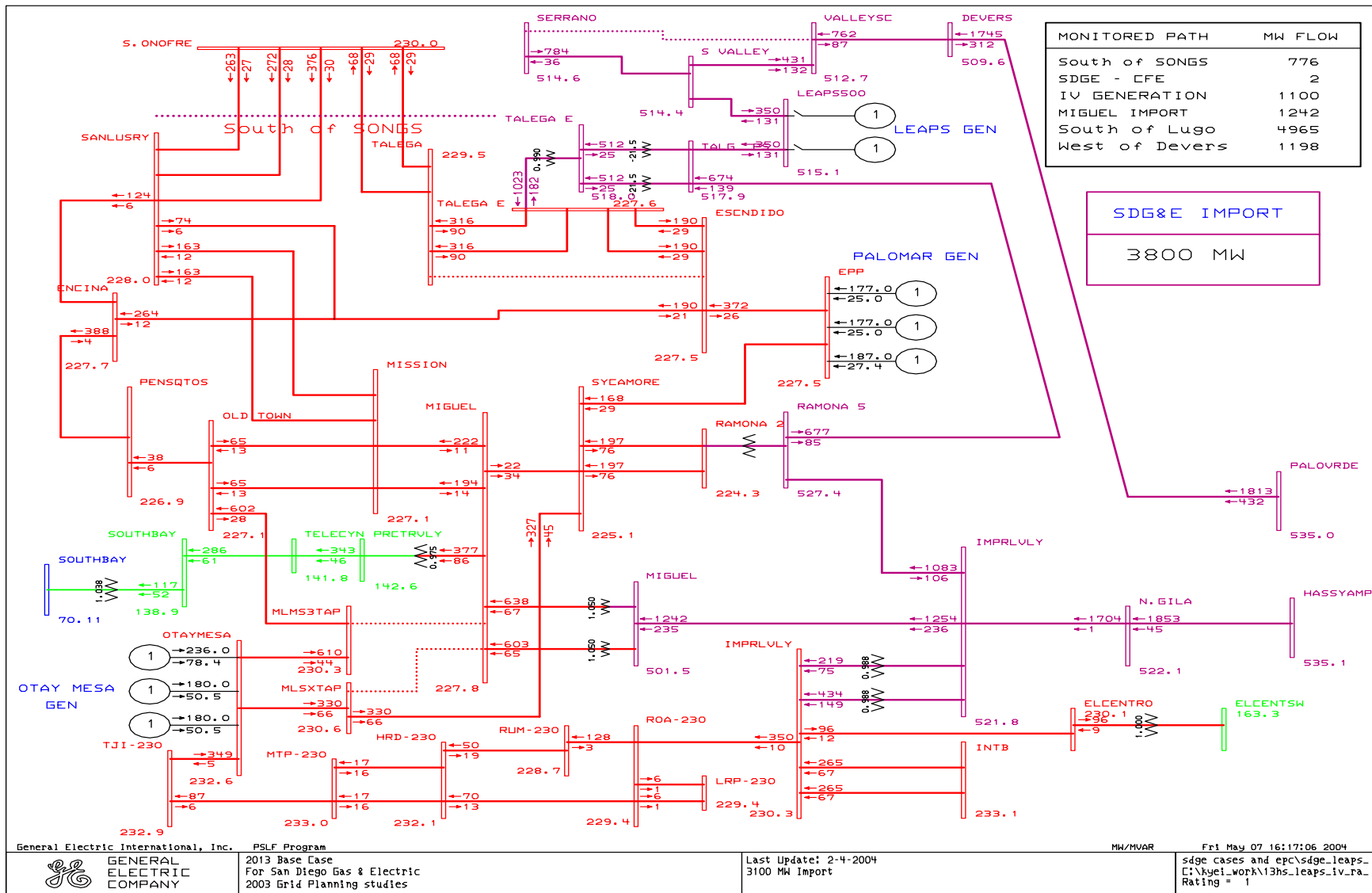


Figure 10: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, 2013 case, with both the LEAPS and ISEP projects linked through a new Talega/Escondido-Ramona 500 kV line (3800 MW San Diego import)

## **N-1-1 Study Results (SWPL Out-of-service analysis)**

- I. Hassyampa -N. Gila 500 kV line section out- of- service case
  - a) ISEP project with a 3600 MW San Diego Import (2013)
    - Critical Contingency: Talega-S. Onofre #1 & 2 230 kV lines
    - Limiting facility: Talega –S. Onofre #1 & 2 230 kV line (115%)
    - Maximum import achievable: 3000 MW
    - Other comments: None
  - b) LEAPS project with a 3600 MW San Diego Import (2013)
    - Critical Contingency: Imperial Valley- Miguel 500 kV line
    - Limiting facility: Palo Verde- Devers 500 kV line (102 % Normal rating)
    - Maximum import achievable: 3450 MW
    - Other comments: Post-transient voltage violations observed in San Diego service territory with Imperial Valley-Miguel 500 kV outage.
  - c) LEAPS and ISEPS combined project with a 3800 MW San Diego Import
    - Critical Contingency: Imperial Valley- Miguel 500 kV line
    - Limiting facility: Palo Verde- Devers 500 kV line (104 % Normal rating)
    - Maximum import achievable: 3450 MW
    - Other comments: Post-transient voltage violations observed in San Diego service territory with Imperial Valley-Miguel 500 kV outage.
- II. Imperial Valley –Miguel 500 kV line section out- of- service case
  - a) ISEP project with 3600 MW San Diego Import (2013)
    - Critical Contingency: Imperial Valley-Ramona 500 kV line
    - Limiting facility: Ramona 500/230 kV transformer (117% Normal rating)
    - Maximum import achievable: 3300 MW
    - Other comments: To achieve 3300 MW, all the generators connected to Imperial Valley must be offline.
  - b) LEAPS project with a 3600 MW San Diego Import (2013)
    - Critical Contingency: None
    - Limiting facility: Old Town #1 & 2 230/69 kV transformers (104 % Normal rating)
    - Maximum import achievable: 3300 MW
    - Other comments: None
  - c) LEAPS and ISEPS combined project with a 3800 MW San Diego Import
    - Critical Contingency: None
    - Limiting facility: Sycamore 230/138 kV transformer (117 % Normal rating)
    - Maximum import achievable: 3450 MW

- Other comments: Generators connected to Imperial Valley must be offline to achieve this import level.

Note: The import levels achieved with SWPL out-of-service cases are contingent to the implementation of the system improvements identified under the post-project cases for each transmission alternative.

### **Sensitivity Study- LEAPS project with 500 MW pump storage plant**

- Starting Case: LEAPS project with 3600 MW Import (2013)
- Maximum import: 3600 MW
- Critical contingency: Hassyampa- N. Gila 500 kV line
- Limiting Facility: Mission 230/69 kV transformer (100% normal rating)
- Voltage support required: ~350 MVAR at South Bay
- System improvements required:
  - i) Replace Old Town #1 &2 230/69 kV transformers (115%) or add a third 230/69 kV bank
  - ii) Replace Penasquitos #2 230/69 kV transformer (107%) or add a new 230/69 kV bank
  - iii) Replace Sycamore #1 &2 230/69 kV transformer (109%) or add a new 230/69 kV bank
  - iv) Re-conductor Kettner-B 69 kV line (133%)
  - v) Re-conductor Old Town-Kettner 69 kV line (123%)
  - vi) Re-conductor Miguel-Proctor Valley 138 kV line (105%)
  - vii) Re-conductor South Bay-Telegraph Canyon 138 kV line (102%)
  - viii) Re-conductor Sycamore-Carlton Hills Tap 138 kV line (122%)
  - ix) Re-conductor NAVSTMTR-Division 69 kV line (120%)
- G-1/N-1 criteria: Satisfied
- Other comments: None

Figure 11 depicts the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 3600 MW import in 2013 for the LEAPS project with the 500 MW pump storage plant.

The reliability benefits to be derived from the LEAPS project with the 500 MW pump storage plant are:

- ✓ Additional Var support at Valley 500 kV
- ✓ Additional MW for dispatch during generation cycle
- ✓ About 130 MW reduction on West of Devers flow during the generation cycle of the pump storage scheme
- ✓ About 250 MW reduction on South of Lugo flow during the generation cycle of the pump storage scheme

Note: The impact of pumping cycle on the reliability of California ISO grid was not evaluated in this study.

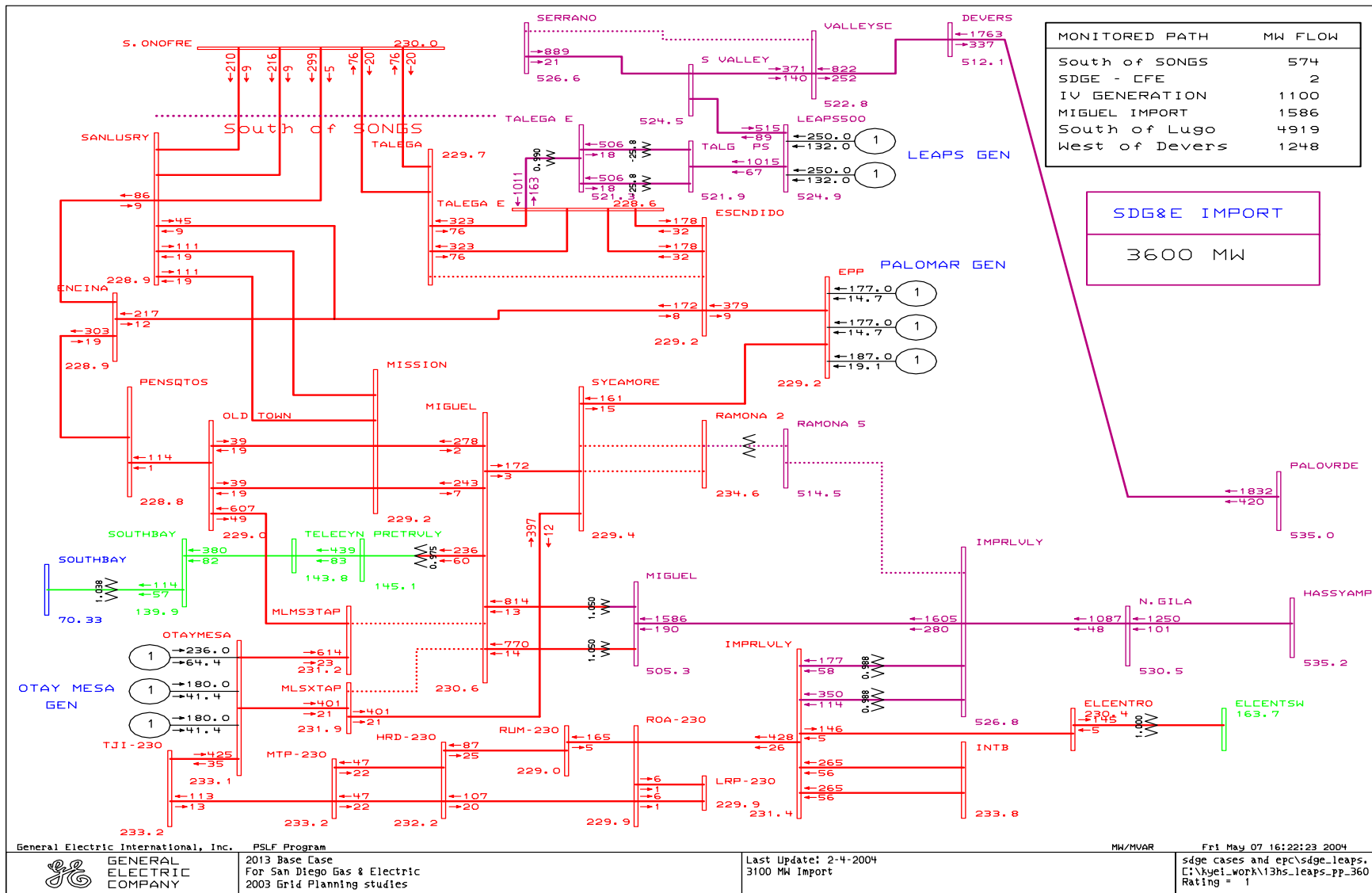


Figure 11: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, 2013 case with the LEAPS project including the 500 MW pumped storage plant (3600 MW San Diego import)

## Sensitivity Study- Otay Mesa generating facility terminating at South Bay and Sycamore Canyon

- a) Imperial Valley –Ramona 500 kV line (ISEP project)
- 1) ISEP project without additional facility
    - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
    - Maximum import with ISEP project: 2550 MW
    - Limiting Facility: Sycamore #1 &2 230/69 kV transformers (100% normal rating)
  
  - 2) ISEP project with a new Sycamore 230/69 kV transformer
    - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
    - Maximum import: 3820 MW
    - Limiting Facility: Sycamore 230/138 kV transformers (100% normal rating)
    - Critical Contingency: Hassyampa-N. Gila 500 kV line
    - Voltage Support required: ~200 MVAR at South Bay
    - System improvements required:
      - i) Re-conductor Scripps - Sycamore 69 kV line (137% normal rating)
      - ii) Re-conductor Pomerado - Poway 69 kV line (113% normal rating)
      - iii) Re-conductor Elliot-Sycamore 69 kV line (150%)
      - iv) Re-conductor Mira Sorrento - Penasquitos 138 kV line (134%)
      - v) Re-conductor Sycamore - Chcarita 138 kV line (128%)
      - vi) Re-conductor Sycamore - Carlton Hills Tap 138 kV line (144%)
      - vii) Install SPS to trip load for Talega - S. Onofre #1 & 2 230 kV outage. The outage of Talega-S. Onofre #1&2 230 kV line overloads:
        - ✓ Escondido-Talega 230 kV line (107%)
        - ✓ Ocean Side Tap - Stuart Tap 69 kV line (109%)
        - ✓ Laspulgs - Stuart Tap 69 kV line (103%)
    - G-1/N-1 criteria: Satisfied
    - Other comments: No SPS is needed for IV-Miguel 500 kV line outage.
  
  - 3) ISEP project with a new Sycamore 230/69 kV transformer
    - Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
    - Maximum import: 3600 MW
    - Limiting Facility: None
    - Critical Contingency: Hassyampa-N. Gila 500 kV
    - Voltage Support required: ~150 MVAR at South Bay
    - System improvements required:

- i) Re-conductor Scripps - Sycamore 69 kV line (131% normal rating)
- ii) Re-conductor Pomerado - Poway 69 kV line (112% normal rating)
- iii) Re-conductor Elliot-Sycamore 69 kV line (144%)
- iv) Re-conductor Sycamore - Carlton Hills Tap 138 kV line (146%)
- v) Install SPS to trip load for Talega-S. Onofre #1 & 2 230 kV outage.  
 The outage of Talega - S. Onofre #1&2 230 kV line overloads:
  - ✓ Escondido -Talega 230 kV line (106%)
  - ✓ Ocean Side Tap-Stuart Tap 69 kV line (111%)
  - ✓ Laspulgs - Stuart Tap 69 kV line (104%)
- G-1/N-1 criteria: Satisfied
- Import Limit with SWPL out of service:
  - ✓ 3000 MW with Hassyampa-N. Gila section out of service
  - ✓ 3100 MW with IV-Miguel section out of service
- Other comments: No SPS is needed for IV-Miguel 500 kV outage

Figure 12 depicts the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 3600 MW import in 2013 with ISEP project (Otay Mesa-South Bay connection).

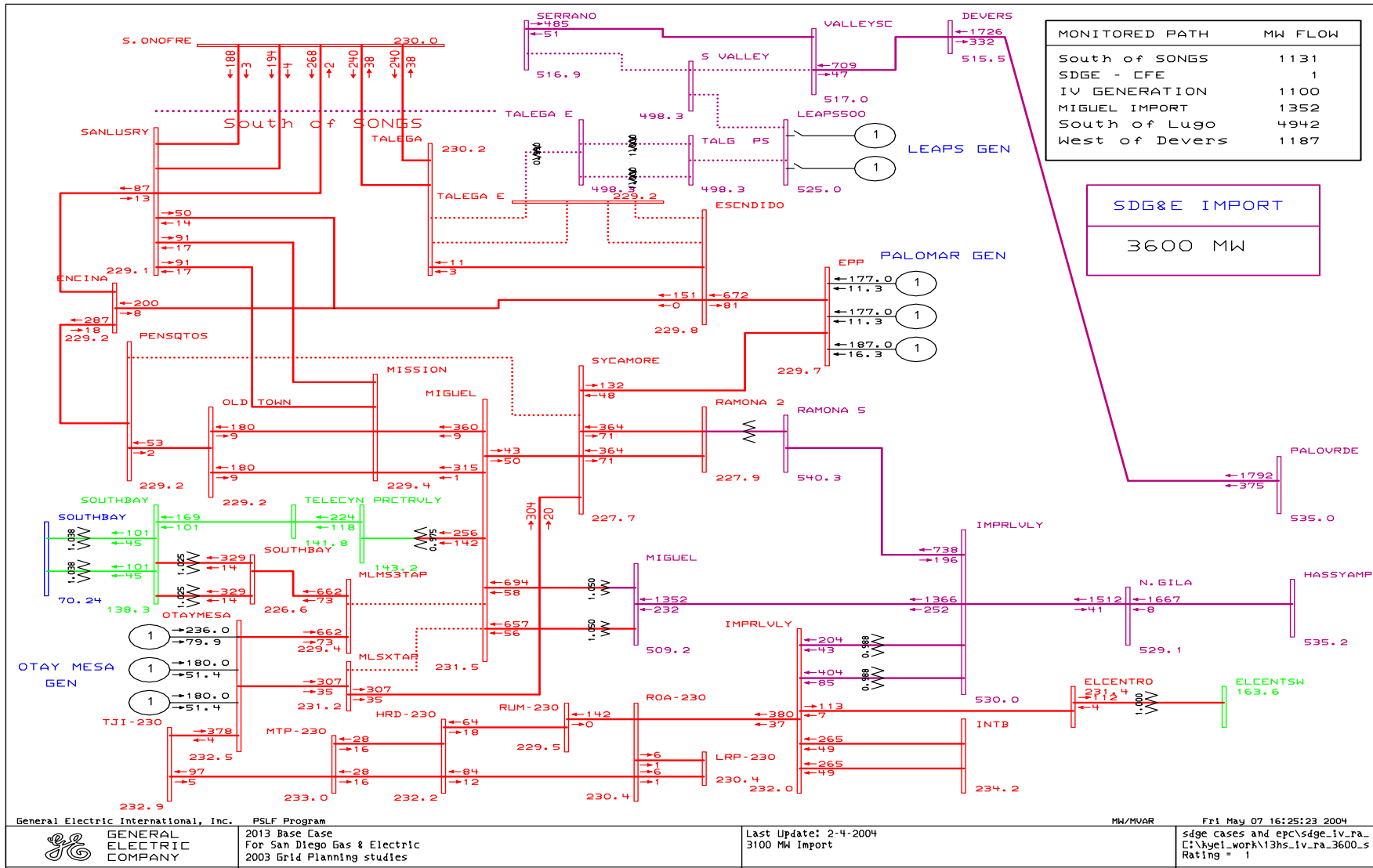


Figure 12: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, under the 2013 case with the ISEP project (3600 MW San Diego import, Otay Mesa-South Bay Connection)

b) Talega/Escondido –Valley/Serrano 500 kV line (LEAPS project without the 500 MW pump storage plant)

1) LEAPS project without additional facility additions

- Starting Case: 2850 MW San Diego Import (2013) with South Bay retired
- Maximum import with LEAPS project: 3600 MW
- Limiting Facility: Sycamore #1 &2 230/69 kV transformers (100% normal rating)
- Critical Contingency: Imperial Valley –Miguel 500 kV line
- Voltage support required: ~150 MVAR at South Bay and 400 MVAR at Devers
- System improvements required:
  - i) Replace Sycamore #1 &2 230/69 kV transformers (111%) or add a third bank
  - ii) Re-conductor Scripps-Sycamore 69 kV line (109% normal rating)
  - iii) Re-conductor Mira Sorrento-Penasquitos 138 kV line (111%)
  - iv) Re-conductor Sycamore – Carlton Hills Tap 138 kV line (126%)
  - v) Re-conductor Sycamore - Chcarita 138 kV line (102%)
- G-1/N-1 criteria: Satisfied
- Import Limit with SWPL out of service:
  - ✓ 3600 MW with Hassyampa-N. Gila section out of service
  - ✓ 3600 MW with IV-Miguel section out of service
- Other comments: Higher import limit achievable with a third 230/69 kV transformer bank at Sycamore.

Figure 13 depicts the power flow map (all lines in service) for major 500 and 230 kV transmission lines in the San Diego area for a 3600 MW import in 2013 with the LEAPS project (Otay Mesa-South Bay connection).

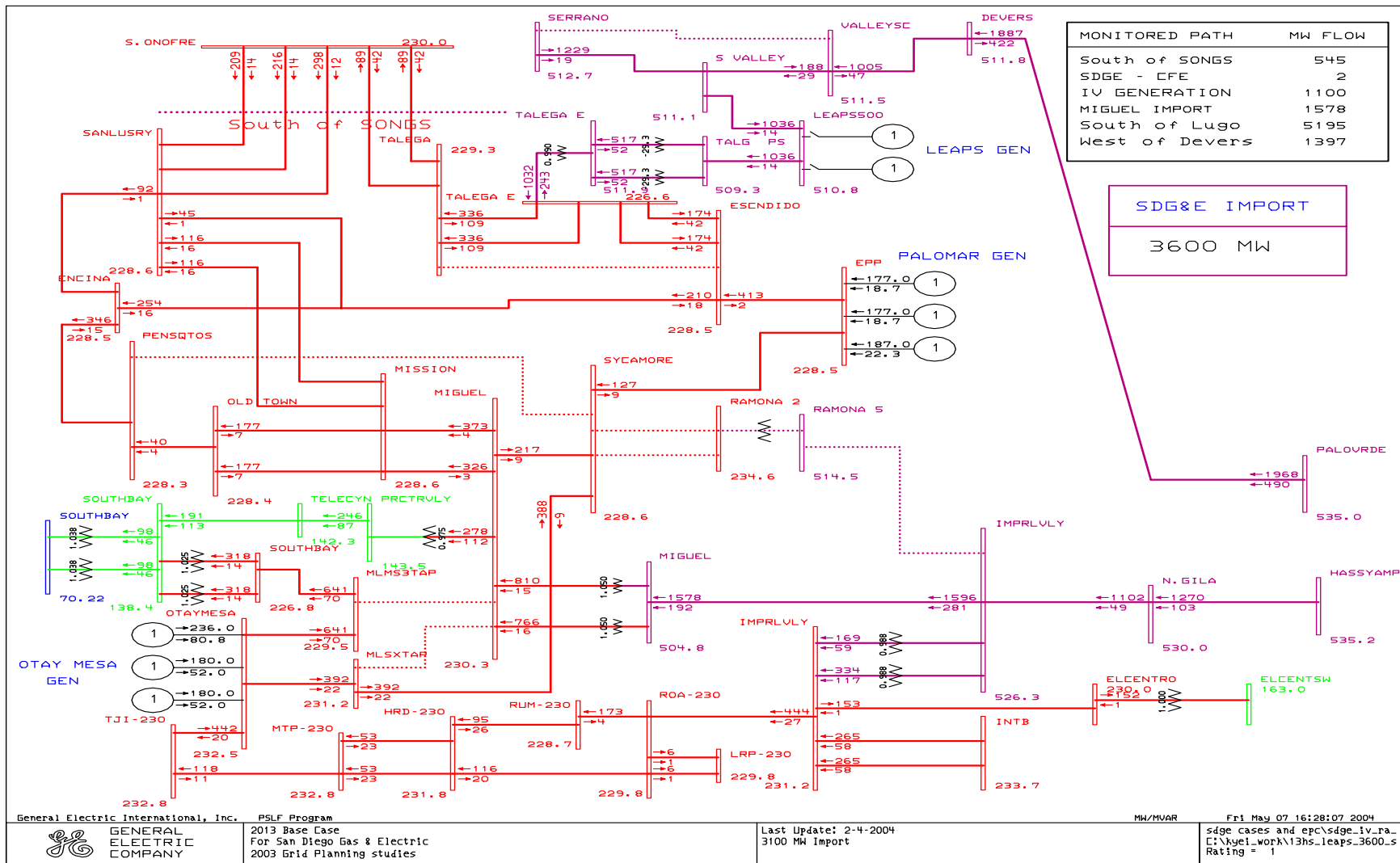


Figure 13: Power Flow Map depicting major 500 and 230 kV transmission lines in the San Diego Area, 2013 case for the LEAPS project (3600 MW San Diego import, Otay Mesa-South Bay Connection)

## Summary of Study Results

Table1: Comparative Reliability Evaluation of ISEP, LEAPS and ISEP/LEAPS Projects (Otay Mesa-Old Town Connection)

Items	Projects		
	ISEP	LEAPS	Combined ISEP and LEAPS
San Diego Import limit	3600 MW	3600 MW	3800 MW
Import limit with SWPL out- of- service	<ul style="list-style-type: none"> <li>➤ 3000 MW for Hassyampa-N. Gila section</li> <li>➤ 3300 MW for IV-Miguel section</li> </ul>	<ul style="list-style-type: none"> <li>➤ 3450 MW for Hassyampa-N. Gila section</li> <li>➤ 3300 MW for IV-Miguel section</li> </ul>	<ul style="list-style-type: none"> <li>➤ 3450 MW for Hassyampa–N. Gila section</li> <li>➤ 3450 MW for IV-Miguel section</li> </ul>
New facilities required to achieve Import limit	<ul style="list-style-type: none"> <li>➤ Penasquitos –Sycamore 230 kV line</li> <li>➤ Sycamore 230/69 kV transformer</li> <li>➤ Penasquitos 230/69 kV transformer</li> </ul>	<ul style="list-style-type: none"> <li>➤ Miguel 230/138 kV transformer</li> </ul>	<ul style="list-style-type: none"> <li>➤ Sycamore 230/69 kV transformer</li> <li>➤ Ramona –Talega/Escondido 500 kV line</li> </ul>
Facility upgrades required to achieved import limit	<ul style="list-style-type: none"> <li>➤ Old Town #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Kettner-B 69 kV line (N-0, N-1)</li> <li>➤ Pomerado-Poway 69 kV line (N-0)</li> <li>➤ Scripps-Sycamore 69 kV line (N-0)</li> <li>➤ Old Town-Kettner 69 kV line (N-1)</li> <li>➤ Sycamore-Elliot 69 kV line (N-1)</li> <li>➤ Sycamore-Carlton Hills Tap 138 kV line (N-1)</li> <li>➤ Navstmtr-Division 69 kV line (N-1)</li> </ul>	<ul style="list-style-type: none"> <li>➤ Old Town #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Penasquitos #2 230/69 kV transformer (N-1)</li> <li>➤ Sycamore #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Scripps-Sycamore 69 kV line (N-0)</li> <li>➤ Kettner-B 69 kV line (N-1)</li> <li>➤ Old Town–Kettner 69 kV line (N-1)</li> <li>➤ Sycamore-Carlton Hills Tap 138 kV line (N-1)</li> <li>➤ Rincon-Warners 69 kV line (N-1)</li> <li>➤ Miguel-Proctor Valley 138 kV line (N-1)</li> <li>➤ South Bay-Telegraph Canyon 138 kV line (N-1)</li> </ul>	<ul style="list-style-type: none"> <li>➤ Old Town #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Penasquitos #2 230/69 kV transformer (N-1)</li> <li>➤ Kettner-B 69 kV line (N-0, N-1)</li> <li>➤ Old Town–Kettner 69 kV line (N-0, N-1)</li> <li>➤ Scripps-Sycamore 69 kV line (N-0)</li> <li>➤ Elliot-Sycamore 69 kV line (N-0, N-1)</li> <li>➤ Sycamore-Carlton Hills Tap 138 kV line (N-0, N-1)</li> <li>➤ Sycamore-Chicarita 138 kV line (N-1)</li> <li>➤ Navstmtr-Division 69 kV line (N-1)</li> </ul>
SPS required	<ul style="list-style-type: none"> <li>➤ SPS to trip load for Miguel –Mission #1 &amp;2 230 kV lines outages</li> </ul>	<ul style="list-style-type: none"> <li>➤ Existing SPS deployed to trip generation for IV-Miguel Outage</li> </ul>	<ul style="list-style-type: none"> <li>➤ SPS to trip load for Miguel – Mission #1 &amp;2 230 kV outages</li> </ul>
G-1/N-1 satisfied	<ul style="list-style-type: none"> <li>➤ Yes</li> </ul>	<ul style="list-style-type: none"> <li>➤ Yes</li> </ul>	<ul style="list-style-type: none"> <li>➤ Yes</li> </ul>
Voltage Support required	<ul style="list-style-type: none"> <li>➤ ~300 Mvar at South Bay</li> </ul>	<ul style="list-style-type: none"> <li>➤ ~350 Mvar at South Bay</li> <li>➤ ~400 Mvar at Devers 500 kV</li> </ul>	<ul style="list-style-type: none"> <li>➤ ~350 Mvar at South Bay</li> <li>➤ ~400 Mvar at Devers 500 kV</li> </ul>
West of Devers flow	<ul style="list-style-type: none"> <li>➤ 1140 MW</li> </ul>	<ul style="list-style-type: none"> <li>➤ 1386 MW</li> </ul>	<ul style="list-style-type: none"> <li>➤ 1200 MW</li> </ul>
South of Lugo flow	<ul style="list-style-type: none"> <li>➤ 4935 MW</li> </ul>	<ul style="list-style-type: none"> <li>➤ 5182 MW</li> </ul>	<ul style="list-style-type: none"> <li>➤ 4968 MW</li> </ul>

Table 2: Comparative Reliability Evaluation of ISEP Project under different Otay Mesa Generation Connections

Items	ISEP Project	
	Otay Mesa-Old Town Connection	Otay Mesa-South Bay Connection
San Diego Import limit	3600 MW	3600 MW (Could increase to 3820 MW)
Import limit with SWPL out- of- service	<ul style="list-style-type: none"> <li>➤ 3000 MW for Hassyampa-N. Gila section</li> <li>➤ 3300 MW for IV-Miguel section</li> </ul>	<ul style="list-style-type: none"> <li>➤ 3000 MW for Hassyampa-N. Gila section</li> <li>➤ 3100 MW for IV-Miguel section</li> </ul>
New facilities required to achieve Import limit	<ul style="list-style-type: none"> <li>➤ Penasquitos –Sycamore 230 kV line</li> <li>➤ Sycamore 230/69 kV transformer</li> <li>➤ Penasquitos 230/69 kV transformer</li> </ul>	<ul style="list-style-type: none"> <li>➤ Sycamore 230/69 kV transformer</li> </ul>
Facility upgrades required to achieved import limit	<ul style="list-style-type: none"> <li>➤ Old Town #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Kettner-B 69 kV line (N-0, N-1)</li> <li>➤ Pomerado-Poway 69 kV line (N-0)</li> <li>➤ Scripps-Sycamore 69 kV line (N-0)</li> <li>➤ Old Town-Kettner 69 kV line (N-1)</li> <li>➤ Sycamore-Elliot 69 kV line (N-1)</li> <li>➤ Sycamore-Carlton Hills Tap 138 kV line (N-1)</li> <li>➤ Navstmtr-Division 69 kV line (N-1)</li> </ul>	<ul style="list-style-type: none"> <li>➤ Scripps-Sycamore 69 kV line (N-0, N-1)</li> <li>➤ Pomerado-Poway 69 kV line (N-0)</li> <li>➤ Elliot–Sycamore 69 kV line (N-0, N-1)</li> <li>➤ Sycamore-Carlton Hills Tap 138 kV line (N-1)</li> </ul>
SPS required	<ul style="list-style-type: none"> <li>➤ SPS to trip load for Miguel –Mission #1 &amp;2 230 kV lines outages</li> </ul>	<ul style="list-style-type: none"> <li>➤ SPS to trip load for Talega-S. Onofre #1 &amp;2 230 kV outages</li> </ul>
G-1/N-1 satisfied	<ul style="list-style-type: none"> <li>➤ Yes</li> </ul>	<ul style="list-style-type: none"> <li>➤ Yes</li> </ul>
Voltage Support required	<ul style="list-style-type: none"> <li>➤ ~300 Mvar at South Bay</li> </ul>	<ul style="list-style-type: none"> <li>➤ ~150 Mvar at South Bay</li> </ul>
Miguel Import	<ul style="list-style-type: none"> <li>➤ 1356 MW</li> </ul>	<ul style="list-style-type: none"> <li>➤ 1351 MW</li> </ul>

Table 3: Comparative Reliability Evaluation of LEAPS Project under different Otay Mesa Generation Connections

Items	LEAPS Project	
	Otay Mesa-Old Town Connection	Otay Mesa-South Bay Connection
San Diego Import limit	3600 MW	3600 MW
Import limit with SWPL out- of- service	<ul style="list-style-type: none"> <li>➤ 3450 MW for Hassyampa-N. Gila section</li> <li>➤ 3300 MW for IV-Miguel section</li> </ul>	<ul style="list-style-type: none"> <li>➤ 3600 MW for Hassyampa–N. Gila section</li> <li>➤ 3600 MW for IV-Miguel section</li> </ul>
New facilities required to achieve Import limit	<ul style="list-style-type: none"> <li>➤ Miguel 230/138 kV transformer</li> </ul>	<ul style="list-style-type: none"> <li>➤ None</li> </ul>
Facility upgrades required to achieved import limit	<ul style="list-style-type: none"> <li>➤ Old Town #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Penasquitos #2 230/69 kV transformer (N-1)</li> <li>➤ Sycamore #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Scripps-Sycamore 69 kV line (N-0)</li> <li>➤ Kettner-B 69 kV line (N-1)</li> <li>➤ Old Town–Kettner 69 kV line (N-1)</li> <li>➤ Sycamore-Carlton Hills Tap 138 kV line (N-1)</li> <li>➤ Rincon-Warners 69 kV line (N-1)</li> <li>➤ Miguel-Proctor Valley 138 kV line (N-1)</li> <li>➤ South Bay-Telegraph Canyon 138 kV line (N-1)</li> </ul>	<ul style="list-style-type: none"> <li>➤ Sycamore #1 &amp;2 230/69 kV transformer (N-1)</li> <li>➤ Scripps-Sycamore 69 kV line (N-0)</li> <li>➤ Mira Sorrento-Penasquitos 138 kV line (N-1)</li> <li>➤ Sycamore-Carlton Hills Tap 138 kV line (N-1)</li> <li>➤ Sycamore-Chicarita 138 kV line (N-1)</li> </ul>
SPS required	<ul style="list-style-type: none"> <li>➤ Existing SPS deployed to trip generation for IV-Miguel line Outage</li> </ul>	<ul style="list-style-type: none"> <li>➤ Existing SPS deployed to trip generation for IV – Miguel 500 kV line outage</li> </ul>
G-1/N-1 satisfied	<ul style="list-style-type: none"> <li>➤ Yes</li> </ul>	<ul style="list-style-type: none"> <li>➤ Yes</li> </ul>
Voltage Support required	<ul style="list-style-type: none"> <li>➤ ~350 Mvar at South Bay</li> <li>➤ ~400 Mvar at Devers 500 kV</li> </ul>	<ul style="list-style-type: none"> <li>➤ ~150 Mvar at South Bay</li> <li>➤ ~400 Mvar at Devers 500 kV</li> </ul>
West of Devers flow	<ul style="list-style-type: none"> <li>➤ 1386 MW</li> </ul>	<ul style="list-style-type: none"> <li>➤ 1400 MW</li> </ul>
South of Lugo flow	<ul style="list-style-type: none"> <li>➤ 5182 MW</li> </ul>	<ul style="list-style-type: none"> <li>➤ 5198 MW</li> </ul>

## 5.0 Conclusions

The study results revealed the relative reliability benefits of both the ISEP and the LEAPS projects. Both projects would provide for a significant increase in San Diego import capability (from 2850 MW to 3600 MW with all lines in service). Both projects would require additional facilities or upgrades beyond the basic project scope to achieve this 3600 MW import limit.

However, there are differences in the operational flexibility that each option provides. The ISEP project could lead to the elimination of the existing SPS for an Imperial Valley-Miguel 500 kV outage, would require less voltage support additions, and would result in lower loadings on the West of Devers and South of Lugo paths. On the other hand, the LEAPS project would support a higher import limit with a section of SWPL out of service.

A combination of ISEP and LEAPS project provides additional benefits (as depicted in Table 1) such as a 3800 MW import capability.

It is evident from Tables 2 and 3 that the point of interconnection for the Otay Mesa Generating facility significantly impacts the facility requirements for the ISEP and LEAPS projects. With Otay Mesa terminating at South Bay and Sycamore Canyon (in lieu of Old Town and Sycamore Canyon), the total number of new facilities required to achieve a 3600 MW San Diego import capability was reduced for either the ISEP or LEAPS projects.