

ANEXO 1

Escenario de demanda máxima y estación seca del mes de marzo

Evaluación de la Estabilidad del Voltaje - 2008

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1. ANÁLISIS DE FLUJO DE CARGA DEL CASO BASE

1.1. Caso sin Intercambio de potencia en las interconexiones

Archivo: MAR_MAX08.sav

Utilizando las herramientas de análisis del PSS/E, se describen las condiciones de red del presente caso:

| X-- AREA | FROM GENERATION | TO LOAD | TO BUS SHUNT | TO LINE SHUNT | FROM CHARGING | TO NET INT | LOSSES | DESIRED NET INT |
|----------|-----------------|---------|--------------|---------------|---------------|------------|--------|-----------------|
| 2 | 892.3 | 874.0 | 0.0 | 0.0 | 0.0 | 0.3 | 17.9 | 0.0 |
| SALVADOR | 277.8 | 226.1 | -56.2 | 0.0 | 87.4 | -0.2 | 195.4 | |

TRANSMISSION LINE LOADINGS ABOVE 100.0 % OF RATING SET A:

| X----- | FROM BUS | X----- | TO BUS | X----- | CURRENT (MVA) |
|------------------------------|------------------------------|--------|---------|--------|---------------|
| BUS# X-- NAME --X BASKV AREA | BUS# X-- NAME --X BASKV AREA | CKT | LOADING | RATING | PERCENT |
| * NONE * | | | | | |

TRANSFORMER LOADINGS ABOVE 100.0 % OF RATING SET A:

| X----- | FROM BUS | X----- | TO BUS | X----- | MVA | MVA |
|------------------------------|------------------------------|--------|---------|--------|---------|-----|
| BUS# X-- NAME --X BASKV AREA | BUS# X-- NAME --X BASKV AREA | CKT | LOADING | RATING | PERCENT | |
| * NONE * | | | | | | |

BUSES WITH VOLTAGE GREATER THAN 1.0500:

| BUS# X-- NAME --X BASKV AREA | V(PU) | V(KV) | BUS# X-- NAME --X BASKV AREA | V(PU) | V(KV) |
|------------------------------|-------|-------|------------------------------|-------|-------|
| * NONE * | | | | | |

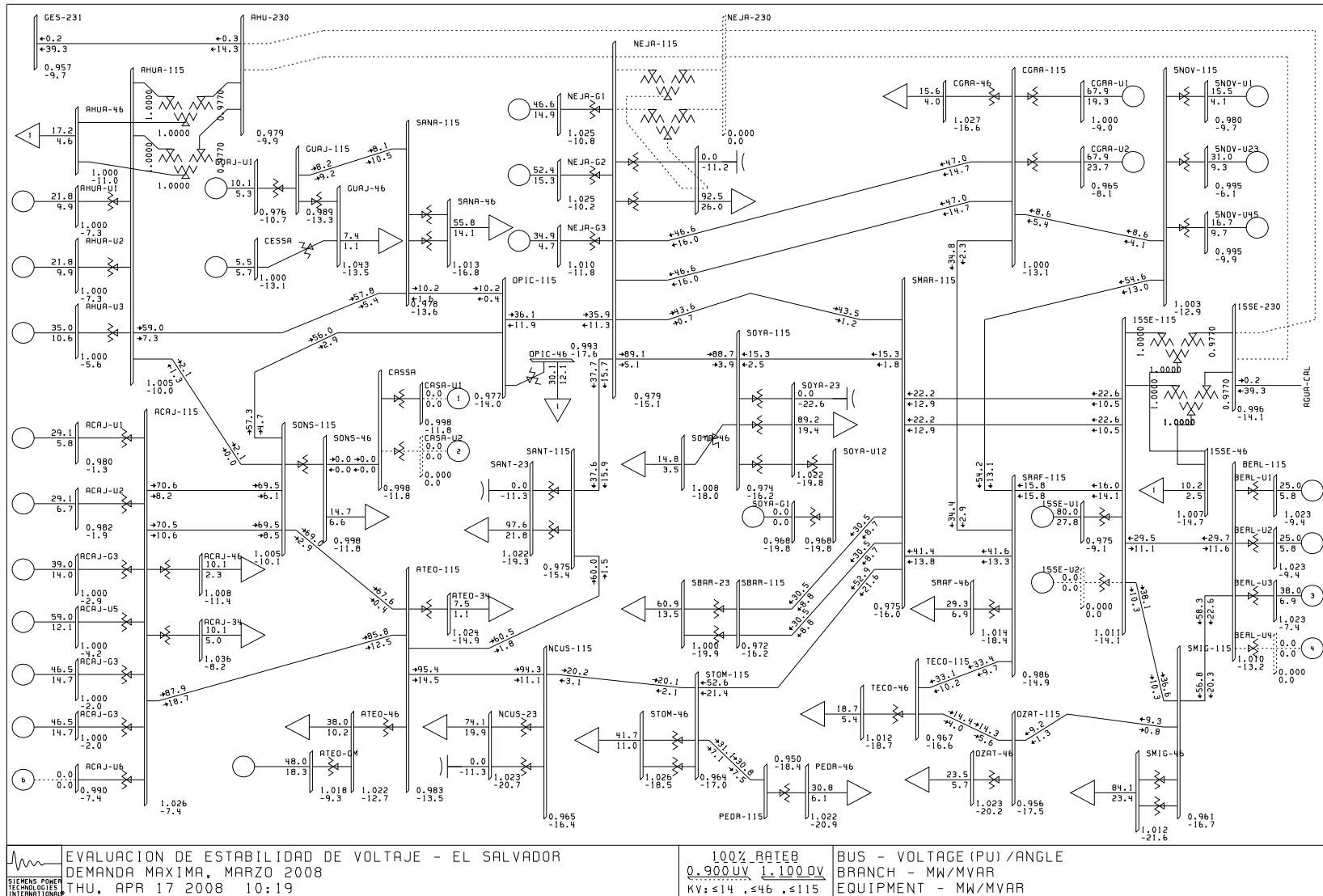
BUSES WITH VOLTAGE LESS THAN 0.9500:

| BUS# X-- NAME --X BASKV AREA | V(PU) | V(KV) | BUS# X-- NAME --X BASKV AREA | V(PU) | V(KV) |
|------------------------------|--------|-------|------------------------------|--------|-------|
| 27471 PEDR-115 | 115.00 | 2 | 0.9494 | 109.18 | |

Se indica que:

- La carga y la generación total en el área de El Salvador, corresponde a un día laboral de demanda máxima esperada de estación seca del mes de marzo;
- En condiciones normales no se presentan sobrecargas de líneas de transmisión;
- No hay transformadores sobrecargados respecto al “rate A” (ajustado al 90% de la capacidad máxima del transformador);
- No hay violaciones por alto voltaje (> 1.05 p.u.);
- En condiciones normales, no existen condiciones de bajo voltaje (< 0.95 p.u.) excepto en la subestación Pedregal. Ver la figura 1.

Figura 1 - Diagrama unifilar de la red del caso intercambio mínimo del escenario de demanda máxima del mes de marzo.

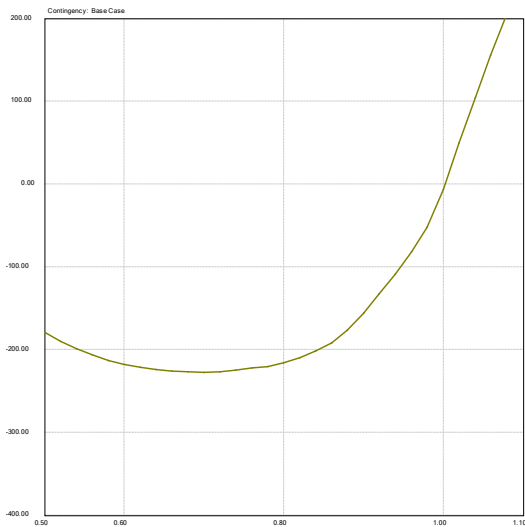


2. IDENTIFICACIÓN DE LAS AREA LOCALES

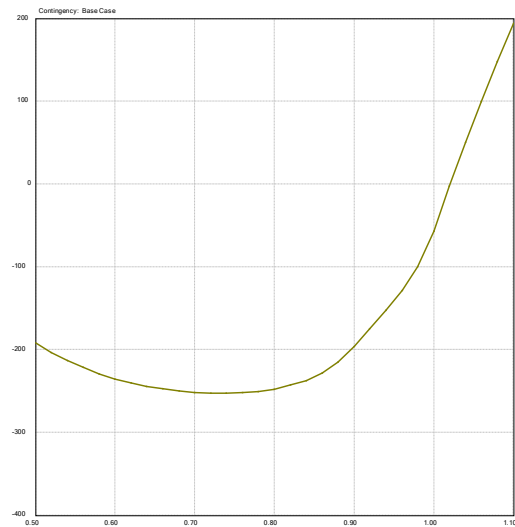
A continuación se obtendrá el factor de efectividad a todos los nodos de transmisión, para lo cual se calcula las curvas Q-V con y sin compensación de reactivos de 50 MVAR en dichos nodos; todas las cargas estarán convertidas y los cambiadores de taps de los transformadores permanecerán fijos.

2.1. Curvas Q-V con y sin compensación:

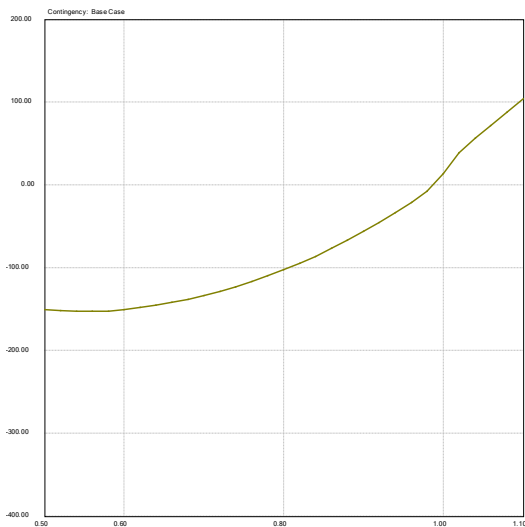
5 de Noviembre, sc, $Q_{min} = -227$ Mvars



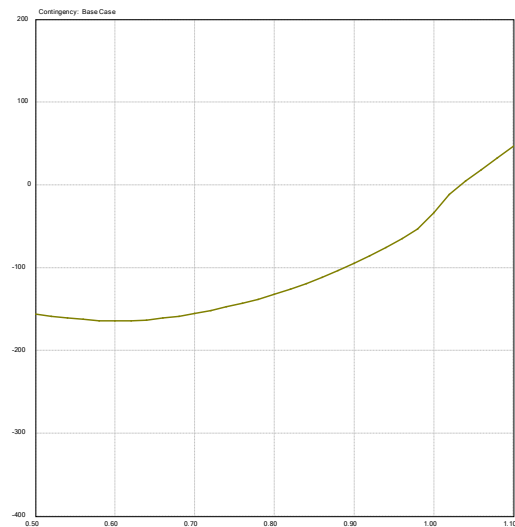
cc, $Q_{min} = -253$ Mvars



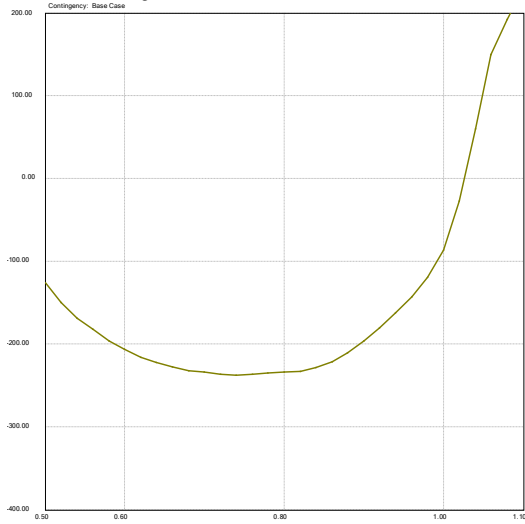
Guajoyo, sc, $Q_{min} = -153$ Mvars



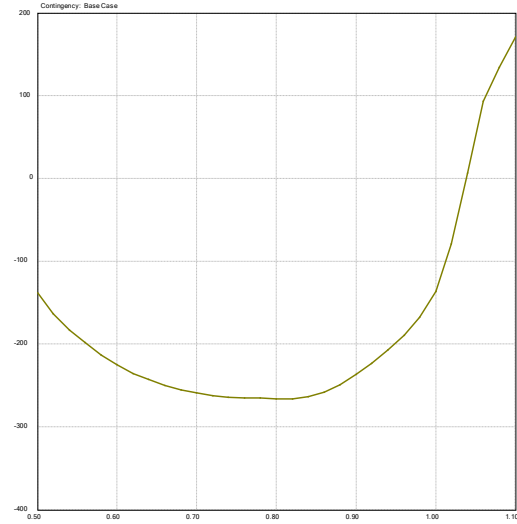
cc, $Q_{min} = -164$ Mvars



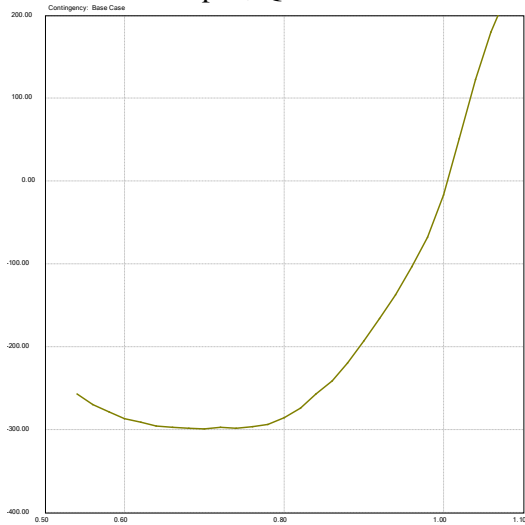
Acajutla, sc, $Q_{min} = -237$ Mvars



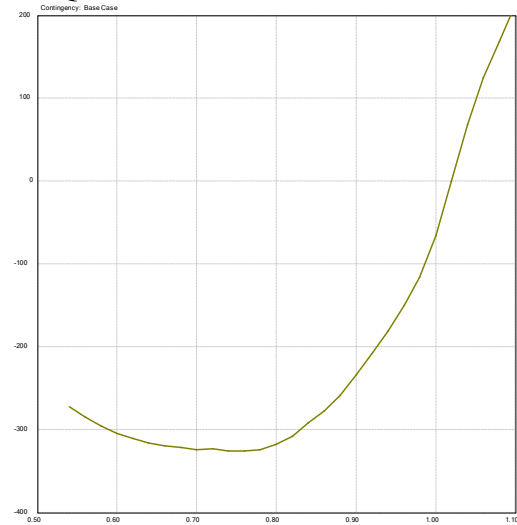
cc, $Q_{min} = -267$ Mvars



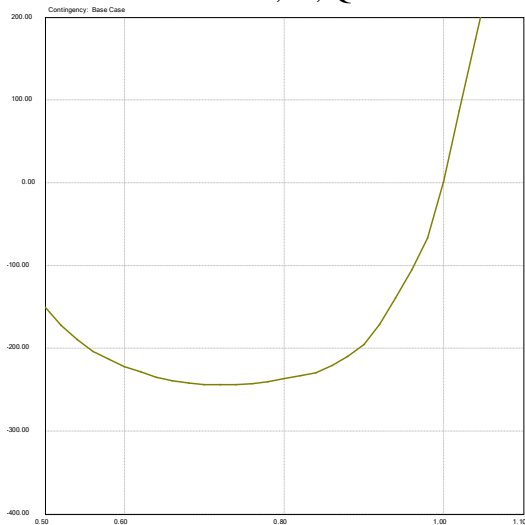
Ahuachapán, $Q_{min} = -300$ Mvars



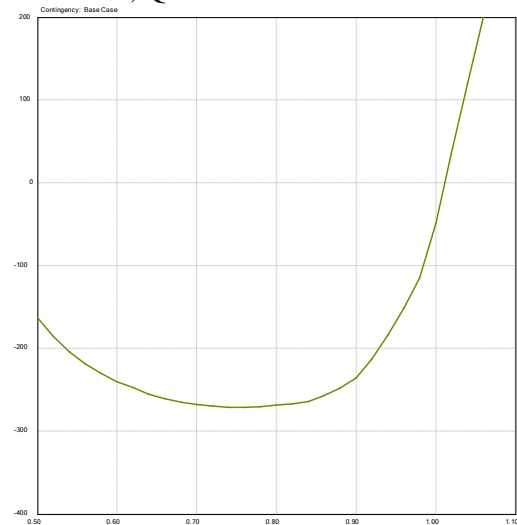
cc, $Q_{min} = -326$ Mvars



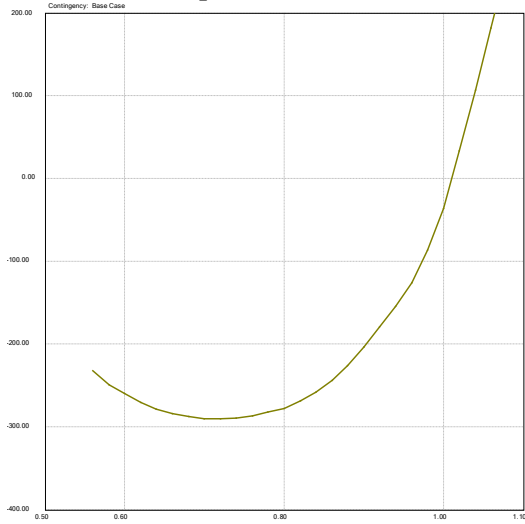
Cerrón Grande, sc, $Q_{min} = -244$ Mvars



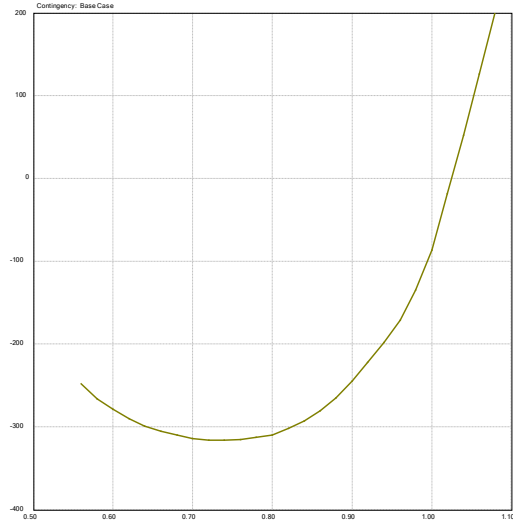
cc, $Q_{min} = -271$ Mvars



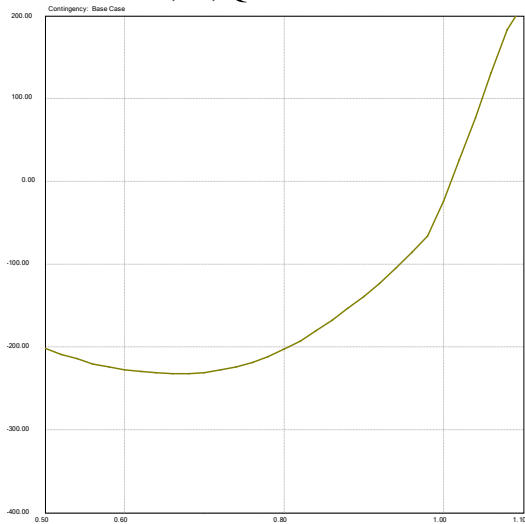
15 de Septiembre, sc, Qmin = -291 Mvars



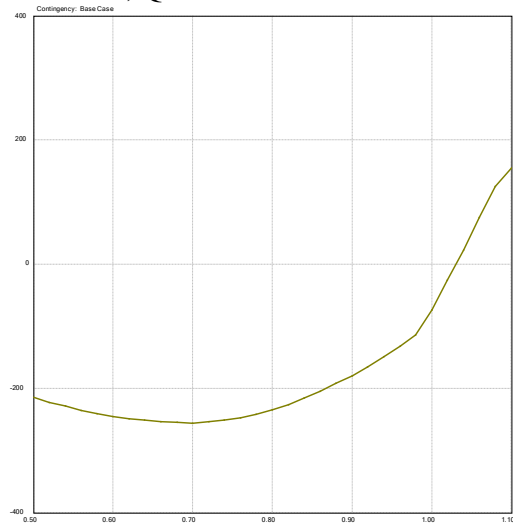
cc, Qmin = -317 Mvars



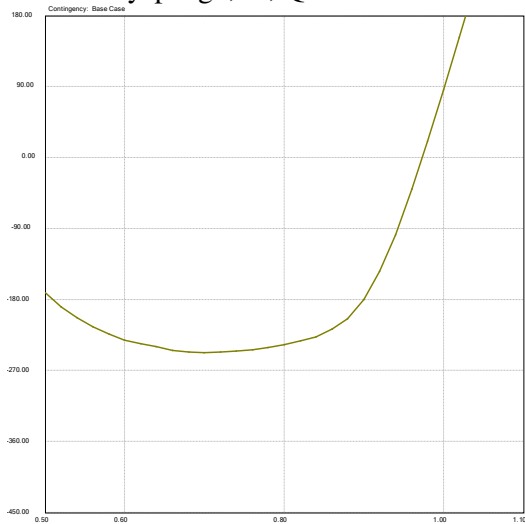
Berlín, sc, Qmin = -232 Mvars



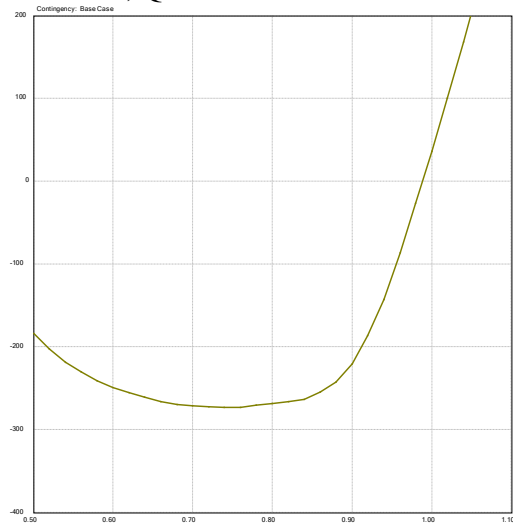
cc, Qmin = -256 Mvars



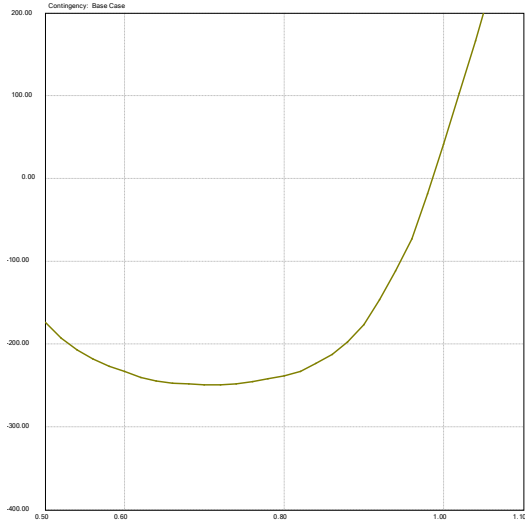
Soyapango, sc, Qmin = -247 Mvars



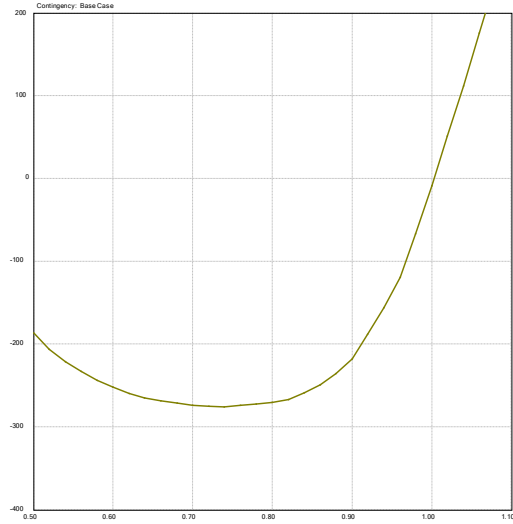
cc, Qmin = -274 Mvars



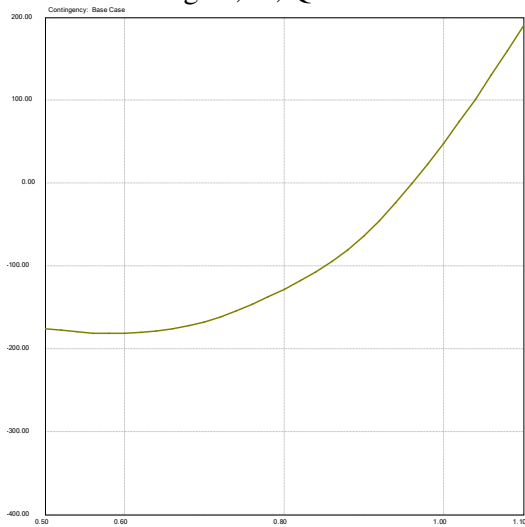
San Rafael, sc, Qmin = -250 Mvars



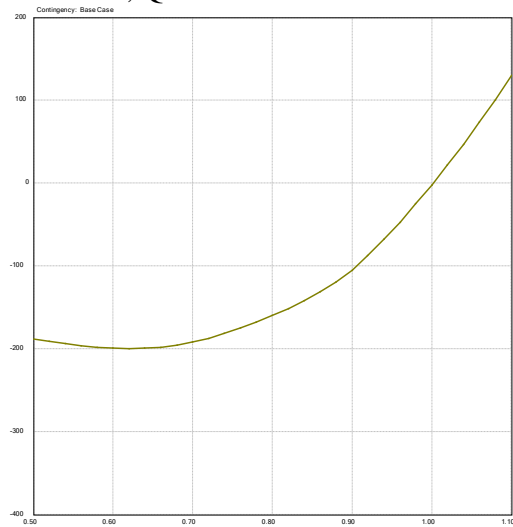
cc, Qmin = -276 Mvars



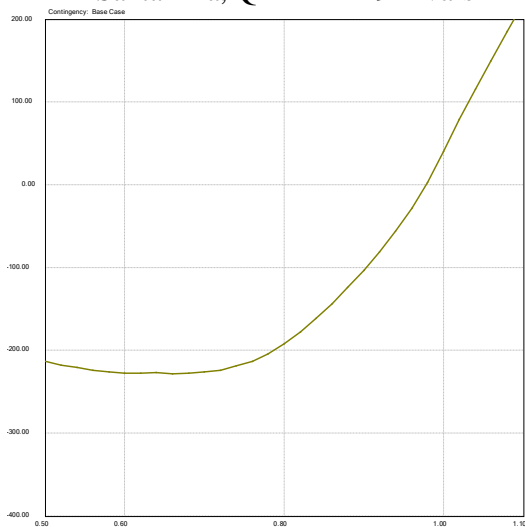
San Miguel, sc, Qmin = -182 Mvars



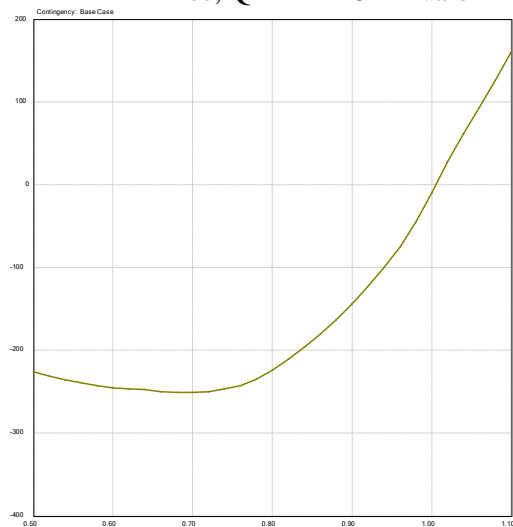
cc; Qmin = -200 Mvars



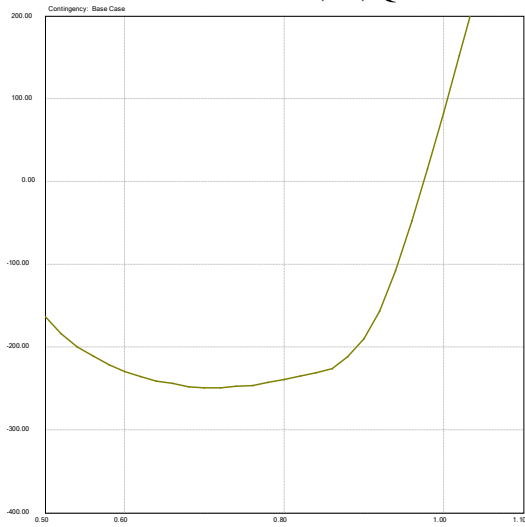
Santa Ana, Qmin = -229 Mvars



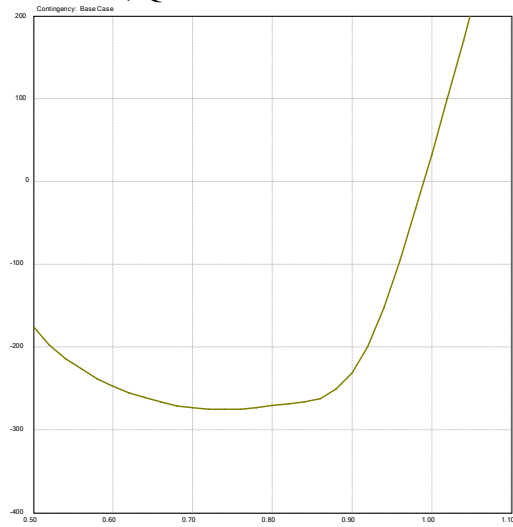
cc, Qmin = -251 Mvars



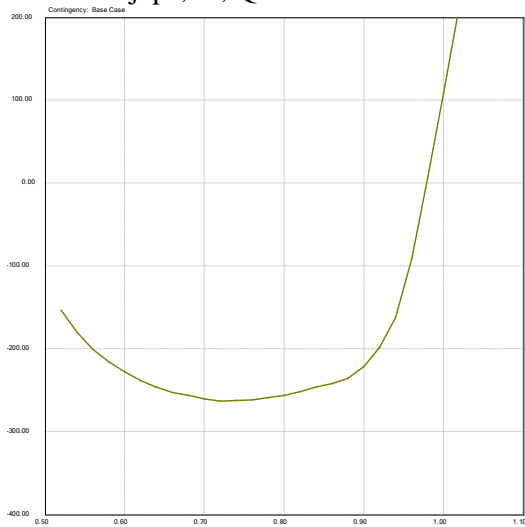
San Antonio Abad, sc, Qmin = -249 Mvars



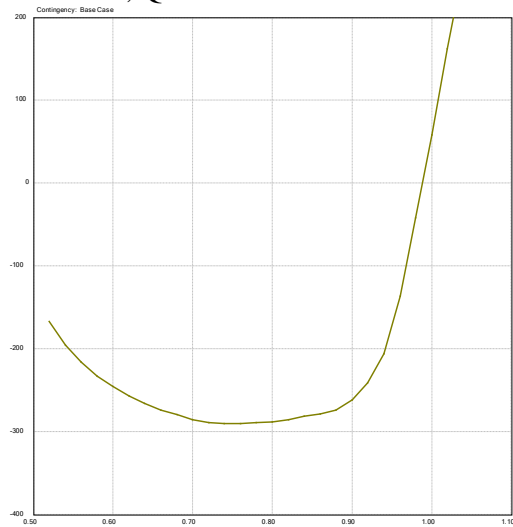
cc, Qmin = -275 Mvars



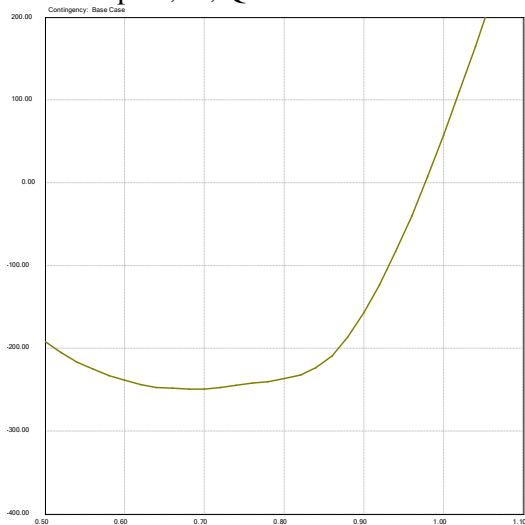
Nejapa, sc, Qmin = -263 Mvars



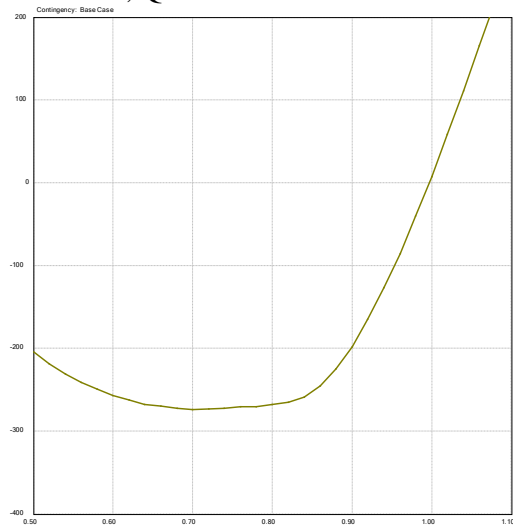
cc, Qmin = -291 Mvars



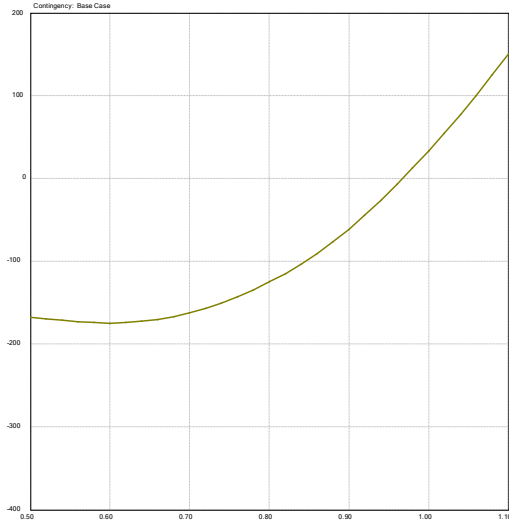
Opico, sc, Qmin = -250 Mvars



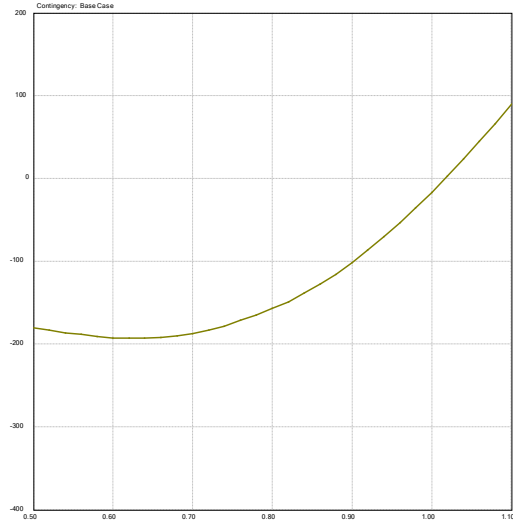
cc, Qmin = -274 Mvars



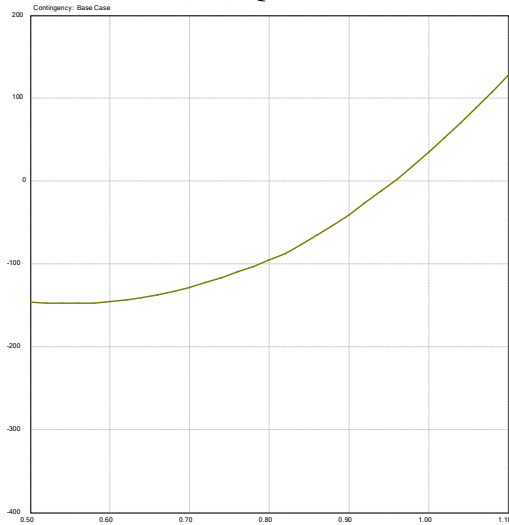
Tecoluca, sc, $Q_{min} = -175$ Mvars



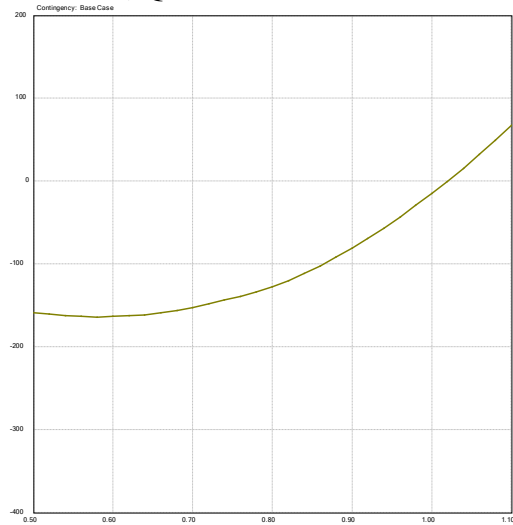
cc, $Q_{min} = -193$ Mvars



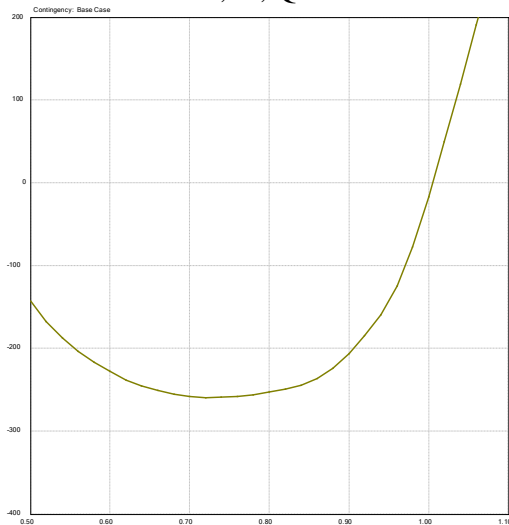
Ozatlán, sc, $Q_{min} = -148$ Mvars



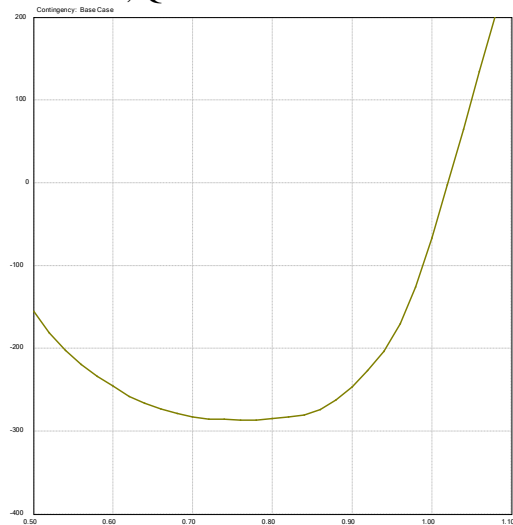
cc; $Q_{min} = -164$ Mvars



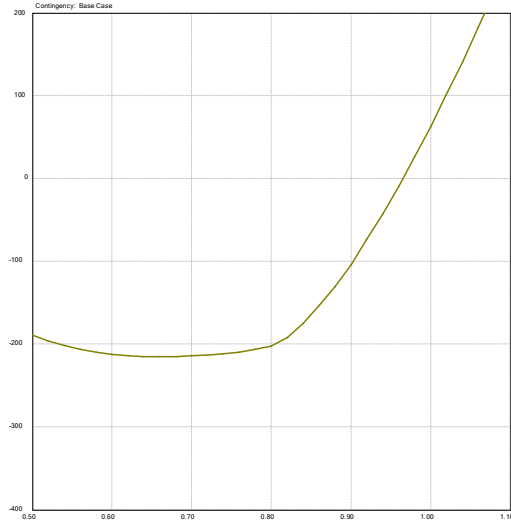
Sonsonate, sc, $Q_{min} = -260$ Mvars



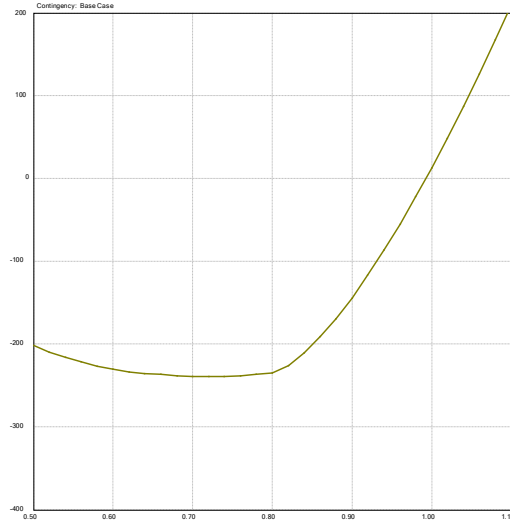
cc, $Q_{min} = -287$ Mvars



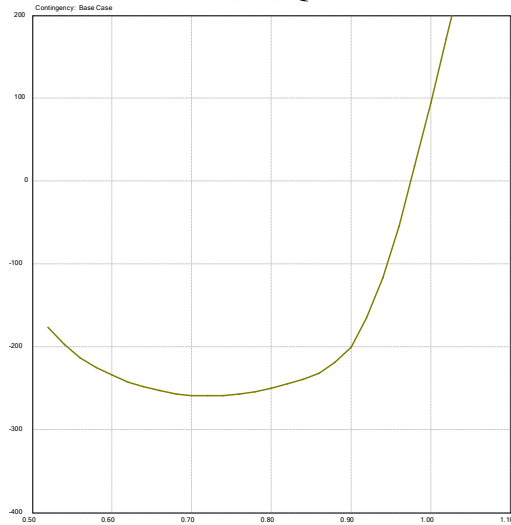
Nuevo Cuscatlán, sc, $Q_{min} = -216$ Mvars



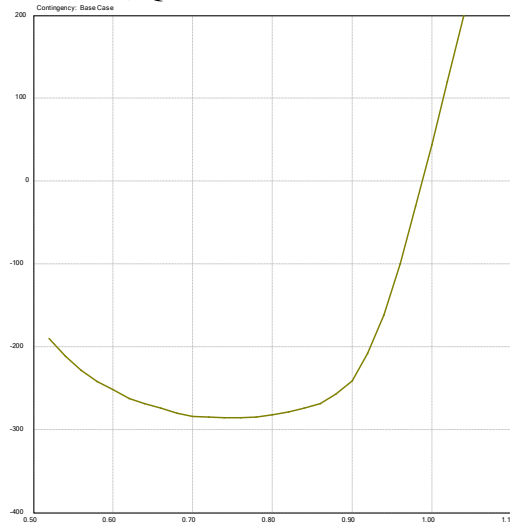
cc; $Q_{min} = -239$ Mvars



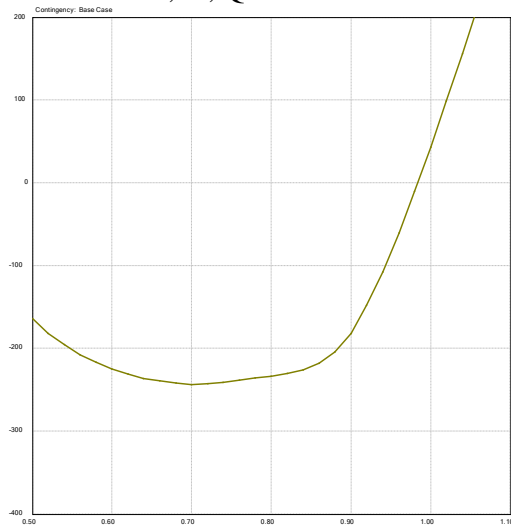
San Martín, sc, $Q_{min} = -260$ Mvars



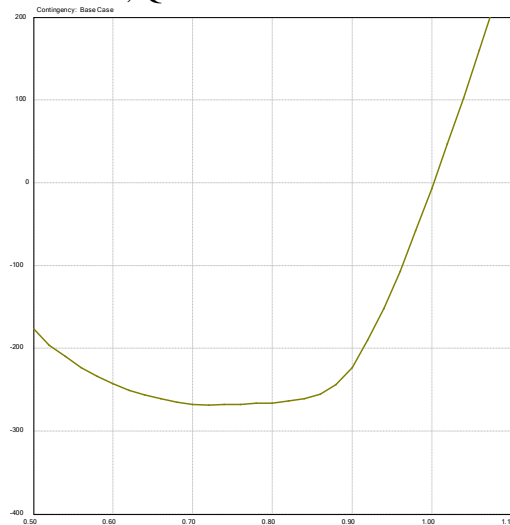
cc; $Q_{min} = -286$ Mvars



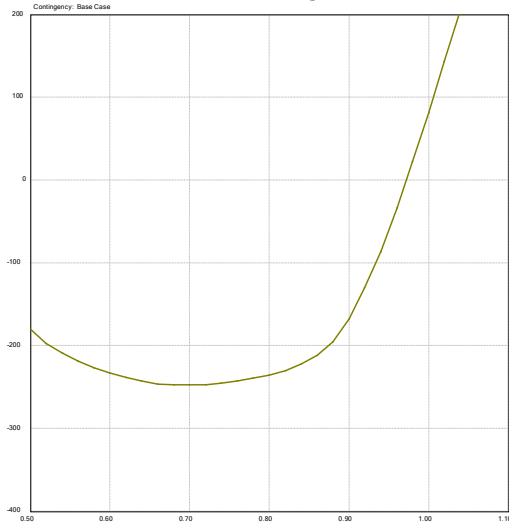
Ateos, sc, $Q_{min} = -244$ Mvars



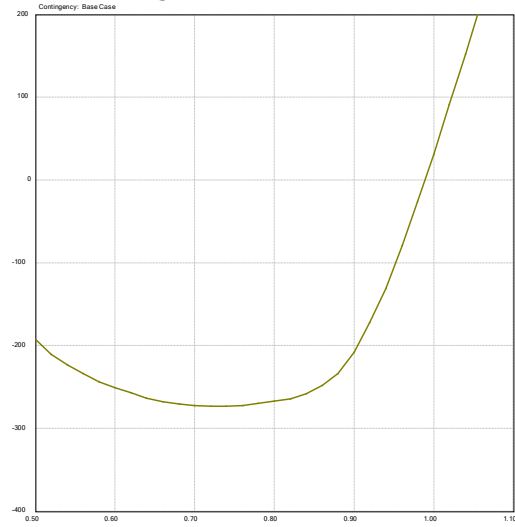
cc, $Q_{min} = -269$ Mvars



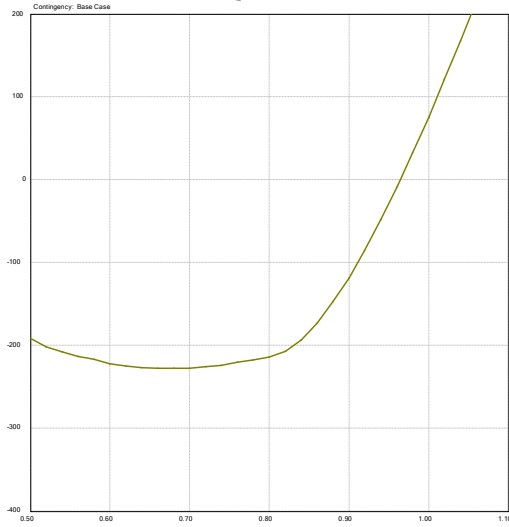
San Bartolo, sc, $Q_{min} = -248$ Mvars



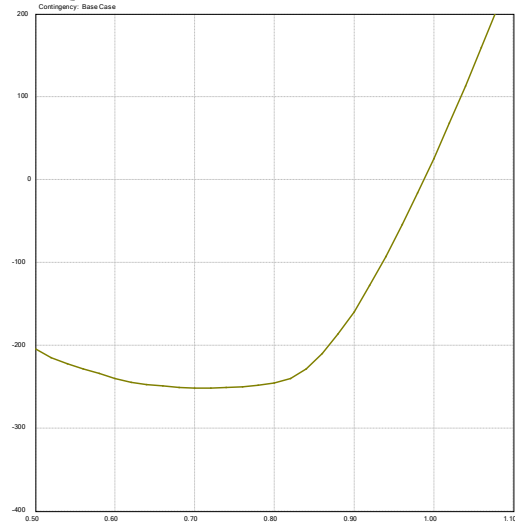
cc; $Q_{min} = -274$ Mvars



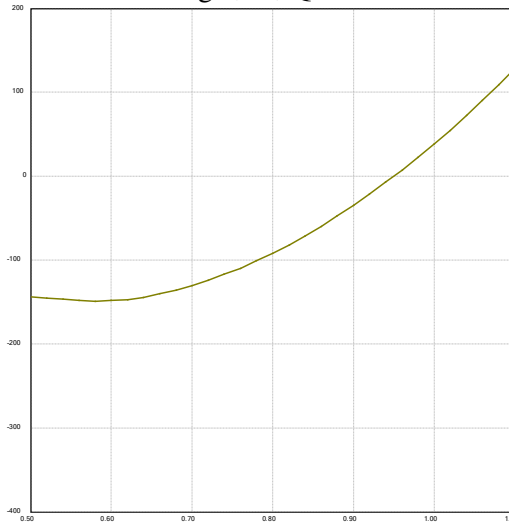
Santo Tomás, sc, $Q_{min} = -228$ Mvars



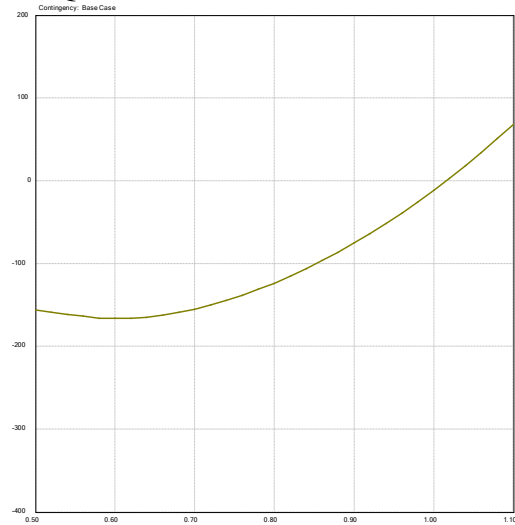
cc, $Q_{min} = -252$ Mvars



El Pedregal, sc, $Q_{min} = -149$ Mvars



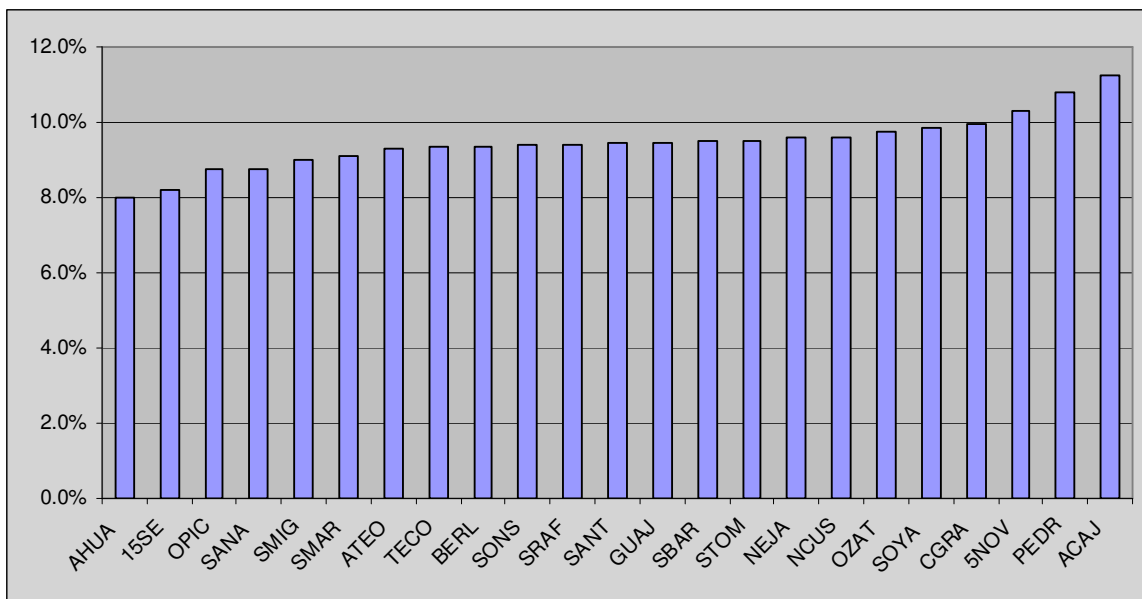
cc; $Q_{min} = -167$ Mvars



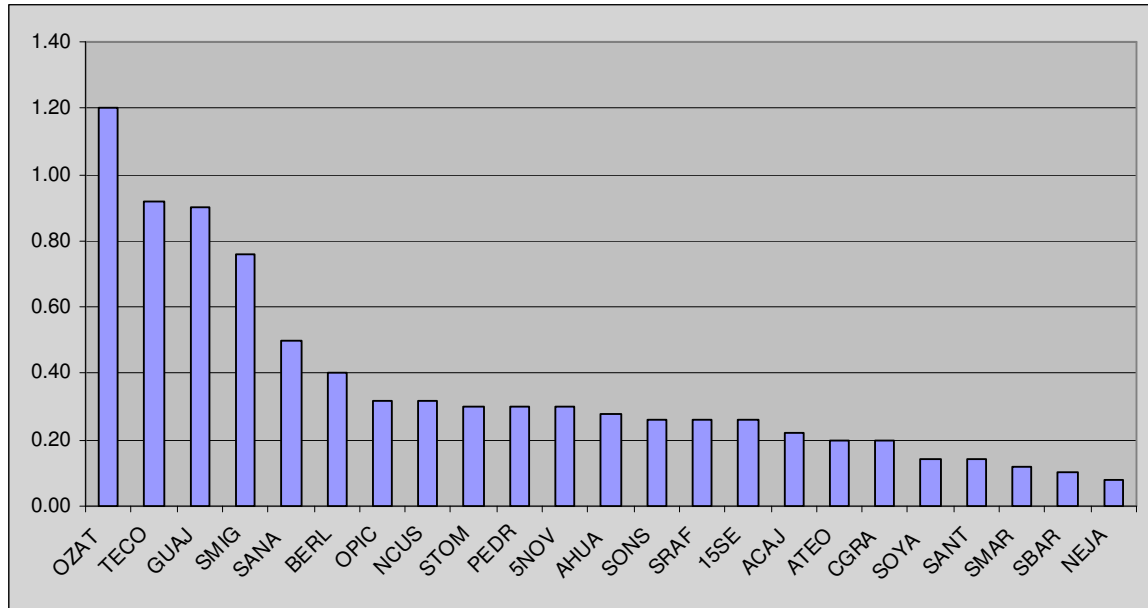
Un resumen de los resultados se presenta a continuación, junto al cálculo del factor de efectividad:

| Demanda máxima | | | Cálculo del factor de sensibilidad | | | Cálculo del factor de efectividad | | |
|----------------|-------|---------|------------------------------------|------------------|-----------|-----------------------------------|-------------------|-----------------------|
| Mes de marzo | | | voltaje sin comp | voltaje con comp | dV/dQ*103 | margen Q sin comp | margen Q con comp | Factor de efectividad |
| Sub | nodo | Voltaje | | | | | | |
| OZAT | 27401 | 115 | 0.956 | 1.016 | 1.20 | -148 | -164 | 9.8% |
| TECO | 27391 | 115 | 0.967 | 1.013 | 0.92 | -175 | -193 | 9.3% |
| GUAJ | 27111 | 115 | 0.989 | 1.034 | 0.90 | -153 | -169 | 9.5% |
| SMIG | 27341 | 115 | 0.96 | 0.998 | 0.76 | -182 | -200 | 9.0% |
| SANA | 27351 | 115 | 0.978 | 1.003 | 0.50 | -229 | -251 | 8.8% |
| BERL | 27211 | 115 | 1.009 | 1.029 | 0.40 | -232 | -256 | 9.4% |
| OPIC | 27381 | 115 | 0.977 | 0.993 | 0.32 | -250 | -274 | 8.8% |
| NCUS | 27421 | 115 | 0.964 | 0.98 | 0.32 | -216 | -239 | 9.6% |
| STOM | 27461 | 115 | 0.963 | 0.978 | 0.30 | -228 | -252 | 9.5% |
| PEDR | 27471 | 115 | 0.949 | 0.964 | 0.30 | -149 | -167 | 10.8% |
| 5NOV | 27101 | 115 | 1.002 | 1.017 | 0.30 | -227 | -253 | 10.3% |
| AHUA | 27161 | 115 | 1.005 | 1.019 | 0.28 | -300 | -326 | 8.0% |
| SONS | 27411 | 115 | 1.005 | 1.018 | 0.26 | -260 | -287 | 9.4% |
| SRAF | 27321 | 115 | 0.986 | 0.999 | 0.26 | -250 | -276 | 9.4% |
| 15SE | 27181 | 115 | 1.01 | 1.023 | 0.26 | -291 | -317 | 8.2% |
| ACAJ | 27131 | 115 | 1.026 | 1.037 | 0.22 | -237 | -267 | 11.2% |
| ATEO | 27441 | 115 | 0.983 | 0.993 | 0.20 | -244 | -269 | 9.3% |
| CGRA | 27171 | 115 | 0.999 | 1.009 | 0.20 | -244 | -271 | 10.0% |
| SOYA | 27301 | 115 | 0.973 | 0.98 | 0.14 | -247 | -274 | 9.9% |
| SANT | 27361 | 115 | 0.975 | 0.982 | 0.14 | -249 | -275 | 9.5% |
| SMAR | 27431 | 115 | 0.975 | 0.981 | 0.12 | -260 | -286 | 9.1% |
| SBAR | 27451 | 115 | 0.971 | 0.976 | 0.10 | -248 | -274 | 9.5% |
| NEJA | 27371 | 115 | 0.978 | 0.982 | 0.08 | -263 | -291 | 9.6% |

Una gráfica de los resultados ordenado por factores de efectividad se muestra a continuación:



Y otra gráfica de los resultados ordenado por factores de sensibilidad se muestra a continuación:



Se indica de mayor a menor, la sensibilidad de variar el voltaje respecto a una inyección de reactivo del nodo. Hay una indicación de área local formado por Ozatlán, Tecoluca y San Miguel.

3. ANÁLISIS DE CONTINGENCIAS DE LA RED DE TRANSMISIÓN

En el presente estudio, se simularán disparos simples y múltiples de todos los elementos de la red nacional.

A continuación se probarán los diferentes escenarios de carga e intercambio que fueron recomendados en el estudio Evaluación de Restricciones de Transmisión 2008.

Los casos que serán analizados son los siguientes:

- Caso A: cero intercambio de potencia en las interconexiones
- Caso B: máxima transferencia Guatemala --> El Salvador 56 MW
- Caso C: máxima transferencia El Salvador --> Guatemala 90 MW
- Caso D: máxima transferencia Honduras --> El Salvador 104¹ MW
- Caso E: máximo Porteo Guatemala 69 MW --> Honduras 100 MW

3.1. Contingencias N-1

3.1.1. Caso A: Cero intercambio de potencia en las interconexiones (caso base)

Archivo: MX_08.raw (versión 26 convertida de MAR_MAX08.sav)

¹ HE + 15SE < 180 MW

Utilizando el programa TPLAN en el modo de “valoración determinística” del análisis de contingencias, se obtienen los siguientes resultados²:

Cuadro 1 – Porcentaje de carga de líneas de transmisión sobrecargadas y voltaje en p.u. de barras con violaciones de voltaje (banda de emergencia).

| Contingencia | | | Línea Sobrecargada | | | | | Barras con Violaciones de Voltaje | | | | |
|--------------|-------------|-----|--------------------|-----------|-----------|-----------|-----------|-----------------------------------|----------|----------|----------|----------|
| Barra Desde | Barra Hacia | ckt | AHUA-SANA | AHUA-SONS | SONS-ATEO | SANA-OPIC | GUAT-AHUA | SMIG-115 | TECO-115 | OZAT-115 | STOM-115 | PEDR-115 |
| BERL-115 | SMIG-115 | 1 | | | | | | 0.886 | | | | |
| SRAF-115 | TECO-115 | 1 | | | | | | | 0.874 | 0.889 | | |
| SMAR-115 | STOM-115 | 1 | | | | | | | | | | 0.889 |

Los resultados indican lo siguiente:

- El TPLAN realizó 56 contingencias de líneas de transmisión y de generación.
- 3 casos de contingencias presentan violación del límite inferior de la banda de emergencia de voltaje (0.90 p.u.).
- No hay casos de colapsos de voltaje, ni de no convergencia en la solución de flujo de potencia.
- Las contingencias que producen bajos voltajes son:
 - Línea Berlín – San Miguel
 - Línea San Martín – Santo Tomás
 - Línea San Rafael Cedros – Tecoluca

Las acciones correctivas para eliminar las violaciones a los parámetros de calidad anteriores son:

- Compensación capacitiva en los siguientes nodos:
 - Tecoluca con 10.8 Mvar
 - Santo Tomás con 10.8 Mvar
 - El Pedregal con 10.8 Mvar

3.1.2. Caso B: Máxima transferencia Guatemala --> El Salvador 56 MW.

Archivo: MX_GE_56.raw (versión 26 convertida de MX_GE_56.sav)

Utilizando el programa TPLAN en el modo de “valoración determinística” del análisis de contingencias, se obtienen los siguientes resultados³:

Cuadro 2 – Porcentaje de carga de líneas de transmisión sobrecargadas y voltaje en p.u. de barras con violaciones de voltaje (banda de emergencia).

| Contingencia | Línea Sobrecargada | Barras con Violaciones de Voltaje |
|--------------|--------------------|-----------------------------------|
|--------------|--------------------|-----------------------------------|

² Tomado del estudio de Evaluación de Restricciones de Transmisión 2008

³ Tomado del estudio de Evaluación de Restricciones de Transmisión 2008

| Barra Desde | Barra Hacia | ckt | AHUA-SANA | AHUA-SONS | SONS-ATEO | SANA-OPIC | 15SE-SMIG | SMIG-115 | TECO-115 | OZAT-115 | STOM-115 | PEDR-115 |
|-------------|-------------|-----|-----------|-----------|-----------|-----------|-----------|----------|----------|----------|----------|----------|
| ACAJ-115 | ATEO-115 | 1 | | | 105% | | | | | | | |
| AHUA-115 | SANA-115 | 1 | | 103% | | | | | | | | |
| BERL-115 | SMIG-115 | 1 | | | | | 0.884 | | | | | |
| SRAF-115 | TECO-115 | 1 | | | | | | 0.870 | 0.885 | | | |
| SMAR-115 | STOM-115 | 1 | | | | | | | | | 0.897 | 0.881 |

Los resultados indican lo siguiente:

- El TPLAN realizó 55 contingencias de líneas de transmisión y generadores.
- Hay 3 casos de sobrecarga de líneas de transmisión
- Hay 3 casos de contingencias que presentan violación del límite inferior de la banda de emergencia de voltaje (0.90 p.u.).
- No hay casos de colapsos de voltaje, ni de no convergencia en la solución de flujo de potencia.

Las acciones correctivas para eliminar las violaciones a los parámetros de calidad anteriores son:

- Reducir la importación de Guatemala a 56 MW
- Compensación capacitiva en los siguientes nodos:
 - San Miguel con 10.8 Mvar
 - Tecoluca con 10.8 Mvar
 - Santo Tomás con 10.8 Mvar ó El Pedregal con 10.8 Mvar

3.1.3. Caso C: Máxima transferencia El Salvador --> Guatemala 90 MW

Archivo: MX_EG_140.raw (versión 26 convertida de MX_EG_140.sav)

Utilizando el programa TPLAN en el modo de “valoración determinística” del análisis de contingencias, se obtienen los siguientes resultados⁴:

```

*** CONTINGENCY RESULTS SUMMARY ***

TOTAL NO. OF CONTINGENCIES TESTED      =    10
  I.   CONVERGED CONTINGENCIES          =    10
  II.  VOLTAGE COLLAPSE CONTINGENCIES  =     0
  III. NOT CONVERGED CONTINGENCIES     =     0

*** FAILURE SUMMARY ***

FAILURE CRITERIA                        NO. OF  WORST  CASE
-----                                FAILURES INDEX  VALUE
-----                                -----
I.   CONVERGED ( 10 CONTINGENCIES) :

  AT LEAST ( 1) BUSES PER ISLAND        0        0 ( 0)
  OVERLOAD ABOVE (1.00) PU OF RATING (B) 0        0 ( 0.00)
  CHANGE IN FLOW ABOVE (999.0%)         0        0 ( 0.0)
  BUS VOLTAGE ABOVE ( 1.10) P.U.        0        0 ( 0.00)
  BUS VOLTAGE BELOW ( 0.90) P.U.        0        0 ( 0.00)
  SUBTOTAL                               0
II.  VOLTAGE COLLAPSE:                  0
III. NOT-CONVERGED (MM > 0.10)         0

TOTAL FAILED CONTINGENCIES :            0
(OFT OF 10 CONTINGENCIES TESTED)

```

Los resultados indican lo siguiente:

⁴ Tomado del estudio de Evaluación de Restricciones de Transmisión 2008

- El TPLAN realizó 48 contingencias de líneas de transmisión y generadores.
- No hay casos de líneas de transmisión sobrecargadas.
- No hay casos de contingencias que presentan violación del límite inferior de la banda de emergencia de voltaje (0.90 p.u.).
- No hay casos de colapsos de voltaje.

3.1.4. Caso D: Máxima transferencia Honduras --> El Salvador 104 MW

Archivo: MX_HE_104.raw (versión 26 convertida de MX_HE_104.sav)

Utilizando el programa TPLAN en el modo de “valoración determinística” del análisis de contingencias, se obtienen los siguientes resultados⁵:

```

*** CONTINGENCY RESULTS SUMMARY ***

TOTAL NO. OF CONTINGENCIES TESTED      =    56
I.   CONVERGED CONTINGENCIES            =    56
II.  VOLTAGE COLLAPSE CONTINGENCIES     =     0
III. NOT CONVERGED CONTINGENCIES        =     0

*** FAILURE SUMMARY ***

FAILURE CRITERIA                        NO. OF   WORST   CASE
-----                                FAILURES INDEX   VALUE
-----                                -
I.   CONVERGED ( 10 CONTINGENCIES) :
      AT LEAST ( 1) BUSES PER ISLAND      0       0 ( 0)
      OVERLOAD ABOVE (1.00) PU OF RATING (B) 0       0 ( 0.00)
      CHANGE IN FLOW ABOVE (999.0%)        0       0 ( 0.0)
      BUS VOLTAGE ABOVE ( 1.10) P.U.      0       0 ( 0.00)
      BUS VOLTAGE BELOW ( 0.90) P.U.      0       0 ( 0.00)
      SUBTOTAL                            0
II.  VOLTAGE COLLAPSE:                   0
III. NOT-CONVERGED (MM > 0.10)          0

TOTAL FAILED CONTINGENCIES :             0
(OUT OF 10 CONTINGENCIES TESTED)

```

Los resultados indican lo siguiente:

- El TPLAN realizó 56 contingencias
- No hay casos de sobrecarga de líneas de transmisión
- No hay casos de violación de la banda de emergencia de voltaje (0.90 pu).
- No hay casos de colapso de voltaje en la solución de flujo de potencia.

3.1.5. Caso E: Máxima transferencia El Salvador--> Honduras 100 MW

Archivo: MX_EH_100.raw (versión 26 convertida de MX_EH_100.sav)

Utilizando el programa TPLAN en el modo de “valoración determinística” del análisis de contingencias, se obtienen los siguientes resultados:

```

*** CONTINGENCY RESULTS SUMMARY ***

TOTAL NO. OF CONTINGENCIES TESTED      =    23
I.   CONVERGED CONTINGENCIES            =    23
II.  VOLTAGE COLLAPSE CONTINGENCIES     =     0

```

⁵ Tomado del estudio de Evaluación de Restricciones de Transmisión 2008

III. NOT CONVERGED CONTINGENCIES = 0

| *** FAILURE SUMMARY *** | | | |
|--|-----------------|-------------|------------|
| FAILURE CRITERIA | NO. OF FAILURES | WORST INDEX | CASE VALUE |
| I. CONVERGED (23 CONTINGENCIES) : | | | |
| AT LEAST (1) BUSES PER ISLAND | 0 | 0 | (0) |
| OVERLOAD ABOVE (1.00) PU OF RATING (B) | 0 | 0 | (0.00) |
| CHANGE IN FLOW ABOVE (999.0%) | 0 | 0 | (0.0) |
| BUS VOLTAGE ABOVE (1.10) P.U. | 0 | 0 | (0.00) |
| BUS VOLTAGE BELOW (0.90) P.U. | 3 | 13 | (0.88) |
| SUBTOTAL | 3 | | |
| II. VOLTAGE COLLAPSE: | 0 | | |
| III. NOT-CONVERGED (MM > 0.10) | 0 | | |
| TOTAL FAILED CONTINGENCIES : | 3 | | |
| (OUT OF 23 CONTINGENCIES TESTED) | | | |

Los resultados indican lo siguiente:

- El TPLAN realizó 57 contingencias
- Hay un casos de sobrecarga de líneas de transmisión
- Hay tres casos de violación de la banda de emergencia de voltaje (0.90 pu).
- No hay casos de colapso de voltaje en la solución de flujo de potencia.

Los resultados son los siguiente:

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT > 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.90, BUSES/ISLD>= 1)

CONTINGENCY 8 : BRANCH 1070

| ----- POST-CONTINGENCY RESULTS ----- | | | | | | | | | |
|--------------------------------------|--------------------|-----------|-----------|----------|----------|--------|---------|---------|-------------------------|
| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM | |
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.89 | (-46, | 39) | 3 | 0.05 | |
| OUTAGES FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B | | | |
| 27211 BERL-115 | 115 27341 SMIG-115 | 115 1 | 61 | 133 | 0.46 | | | | |
| * AREA 2 * | | | | | | | 0.7 | 0.9 | 1.1 |
| VOLTAGE BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | | *-----* | *-----* | *-----* |
| 27341 SMIG-115 | 1.100 | 0.900 | 0.965 | 0.894 | -0.071 | | . | ---- | . |
| VAR | | | | | | | | | GENERATORS ON VAR LIMIT |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT > 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.90, BUSES/ISLD>= 1)

CONTINGENCY 13 : BRANCH 1073

| ----- POST-CONTINGENCY RESULTS ----- | | | | | | | | | |
|--------------------------------------|--------------------|-----------|-----------|----------|----------|--------|---------|---------|-------------------------|
| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM | |
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 2-0.88 | (-49, | 40) | 2 | 0.07 | |
| OUTAGES FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B | | | |
| 27321 SRAF-115 | 115 27391 TECO-115 | 115 1 | 37 | 133 | 0.28 | | | | |
| * AREA 2 * | | | | | | | 0.7 | 0.9 | 1.1 |
| VOLTAGE BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | | *-----* | *-----* | *-----* |
| 27391 TECO-115 | 1.100 | 0.900 | 0.970 | 0.881 | -0.089 | | . | ----- | . |
| 27401 OZAT-115 | 1.100 | 0.900 | 0.960 | 0.896 | -0.064 | | . | ---- | . |
| VAR | | | | | | | | | GENERATORS ON VAR LIMIT |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S

(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.90, BUSES/ISLD>= 1)

CONTINGENCY 18 : BRANCH 1090

```

----- POST-CONTINGENCY RESULTS -----
SOLN  OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER  MM
-      0-0.00    0- 0.0    0-0.00    1-0.89  ( -50,  40)  3  0.03

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27431 SMAR-115 115 27461 STOM-115 115 1    59      266      0.22

* AREA 2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
27471 PEDR-115      1.100    0.900    0.951    0.890    -0.061    .      .      .
VAR                                             GENERATORS ON VAR LIMIT
  
```

El siguiente cuadro resume los resultados:

Cuadro 4 – Porcentaje de carga de líneas de transmisión sobrecargadas y voltaje en p.u. de barras con violaciones de voltaje (banda de emergencia).

| Contingencia | | | Línea Sobrecargada | | | | | Barras con Violaciones de Voltaje | | | | |
|--------------|-------------|-----|--------------------|-----------|-----------|-----------|-----------|-----------------------------------|----------|----------|----------|----------|
| Barra Desde | Barra Hacia | ckt | 15SE-SMAR | AHUA-SONS | SONS-ATEO | SANA-OPIC | 15SE-SMIG | SMIG-115 | TECO-115 | OZAT-115 | STOM-115 | PEDR-115 |
| BERL-115 | SMIG-115 | 1 | | | | | | 0.894 | | | | |
| SRAF-115 | TECO-115 | 1 | | | | | | | 0.881 | 0.896 | | |
| SMAR-115 | STOM-115 | 1 | | | | | | | | | | 0.890 |

Las acciones correctivas para eliminar las violaciones a los parámetros de calidad anteriores son:

- Compensación capacitiva en los siguientes nodos:
 - San Miguel con 10.8 Mvar
 - Tecoluca con 10.8 Mvar
 - El Pedregal con 10.8 Mvar

3.2. Contingencias N-2

3.2.1. Caso A: Cero intercambio de potencia en las interconexiones (caso base)

Archivo: MX_08.raw (versión 26 convertida de MAR_MAX08.sav)

Con el objeto de evitar el analizar los casos menos críticos, primeramente se hizo un análisis de la cantidad de casos de contingencias N-2 se producen en función del límites inferior de voltaje para el cual se considera un abatimiento del voltaje extremo:

| Límite inferior de voltaje en nodos (p.u.) | Número de casos con violación del límite inferior de voltaje | Número de casos con colapso de voltaje | Número de casos de no convergencia |
|--|--|--|------------------------------------|
| 0.90 | 170 | 1 | 2 |
| 0.89 | 169 | 1 | 2 |
| 0.88 | 67 | 1 | 2 |
| 0.87 | 11 | 1 | 2 |
| 0.86 | 5 | 1 | 2 |

Del cuadro anterior, se concluye que los dos casos de “No-convergencia” y que un caso de “colapso de voltaje”, son una constante en todos los escenarios posibles; y que además, como punto de partida, se analizarán los 11 casos de bajo voltaje con respecto a la violación de límite inferior de 0.87 p.u. de voltaje, cuyos resultados se muestran a continuación:

```

*** CONTINGENCY RESULTS SUMMARY ***

TOTAL NO. OF CONTINGENCIES TESTED      = 1825
I.   CONVERGED CONTINGENCIES            = 1822
II.  VOLTAGE COLLAPSE CONTINGENCIES    = 1
III. NOT CONVERGED CONTINGENCIES       = 2

*** FAILURE SUMMARY ***

FAILURE CRITERIA                        NO. OF   WORST   CASE
-----                        FAILURES INDEX   VALUE
I.   CONVERGED ( 1822 CONTINGENCIES) :
      AT LEAST ( 1) BUSES PER ISLAND      0         0 ( 0)
      OVERLOAD ABOVE (1.10) PU OF RATING (B) 12       1248 ( 1.52)
      CHANGE IN FLOW ABOVE (999.0%)        0         0 ( 0.0)
      BUS VOLTAGE ABOVE ( 1.15) P.U.       0         0 ( 0.00)
      BUS VOLTAGE BELOW ( 0.87) P.U.      11       1320 ( 0.74)
      SUBTOTAL                            20
II.  VOLTAGE COLLAPSE:                    1
III. NOT-CONVERGED (MM > 0.10)           2

TOTAL FAILED CONTINGENCIES :              23
(OFT OF 1825 CONTINGENCIES TESTED)

```

Los resultados indican lo siguiente:

- El TPLAN realizó 1825 contingencias de líneas de transmisión y de generación.
- 11 casos de contingencias presentan violación del límite inferior de la banda de emergencia de voltaje (0.87 p.u.).
- Hay 12 casos de violación por sobrecarga de líneas de transmisión, los cuales no son objeto del presente estudio.
- Hay casos 1 caso de colapso de voltaje y 2 casos de no convergencia en la solución de flujo de potencia.

Un resumen detallado de los casos de bajo voltaje se muestra a continuación:

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 954 : BRANCH 1073 ++UNIT 305

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-       0-0.00   0- 0.0   0-0.00   1-0.87  (  57, 19)  3   0.03

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1    36    133    0.27
21211 BERL-U1 13.8          1    25     28

* AREA  2 *
VOLTAGE BUS NAME      MAX.    MIN.    BASE    CONT    DEV.    0.7    0.9    1.1
27391 TECO-115      1.150  0.870  0.967  0.866  -0.101  .      -----  .

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 995 : BRANCH 1073 ++UNIT 306

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-       0-0.00   0- 0.0   0-0.00   1-0.87  (  57, 19)  3   0.01

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1    36    133    0.27
21212 BERL-U2 13.8          2    25     28

* AREA  2 *
VOLTAGE BUS NAME      MAX.    MIN.    BASE    CONT    DEV.    0.7    0.9    1.1
27391 TECO-115      1.150  0.870  0.967  0.866  -0.101  .      -----  .

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1034 : BRANCH 1073 ++UNIT 303

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-       0-0.00   0- 0.0   0-0.00   1-0.86  (  58, 19)  3   0.06

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1    36    133    0.27
21181 15SE-U1 13.8          1    80     80

* AREA  2 *
VOLTAGE BUS NAME      MAX.    MIN.    BASE    CONT    DEV.    0.7    0.9    1.1
27391 TECO-115      1.150  0.870  0.967  0.856  -0.111  .      -----  .

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1109 : BRANCH 1073 ++UNIT 307

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      0-0.00  0- 0.0  0-0.00  1-0.87  (  57, 19)  3   0.03

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1    36   133     133     0.27
21213 BERL-U3 13.8          3    38     40

* AREA  2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
                *-----*-----*-----*-----*
27391 TECO-115    1.150    0.870    0.967    0.865    -0.102    .        -----  .

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1254 : BRANCH 1090 ++BRANCH 1055

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      1-1.02  0- 0.0  0-0.00  2-0.85  (  64, 20)  4   0.05

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27431 SMAR-115 115 27461 STOM-115 115 1    59   266     266     0.22
27131 ACAJ-115 115 27441 ATEO-115 115 1    88   266     266     0.33

OVERLOAD FROM BUS          TO BUS          ID  BASE CONT  ---P.U. FLOWS---
27411 SONS-115 115 27441 ATEO-115 115 1    69  149  1.32  1.12  1.12

* AREA  2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
                *-----*-----*-----*-----*
27461 STOM-115    1.150    0.870    0.963    0.866    -0.097    .        -----  .
27471 PEDR-115    1.150    0.870    0.949    0.850    -0.099    .        -----  .
VAR                                             GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1290 : BRANCH 1086 ++BRANCH 1073

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      0-0.00  0- 0.0  0-0.00  1-0.87  (  62, 20)  3   0.07

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27421 NCUS-115 115 27441 ATEO-115 115 1    98   266     266     0.37
27321 SRAF-115 115 27391 TECO-115 115 1    36   133     133     0.27

* AREA  2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
                *-----*-----*-----*-----*
27391 TECO-115    1.150    0.870    0.967    0.868    -0.099    .        -----  .
VAR                                             GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1311 : BRANCH 1070 ++BRANCH 1065

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
VC-    0-0.00  0- 0.0  0-0.00  6-0.00  (  11, 17)  4   5.00

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B

```

```
27211 BERL-115 115 27341 SMIG-115 115 1      63      133      0.47
27181 15SE-115 115 27341 SMIG-115 115 1      40      133      0.30
```

```
* AREA      2 *
VOLTAGE  BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
          *-----*-----*-----*
24341 SMIG-46 4 1.150 0.870 1.012 0.004 -1.008 ----- .
24391 TECO-46 4 1.150 0.870 1.012 0.698 -0.314 ----- .
24401 OZAT-46 4 1.150 0.870 1.023 0.439 -0.584 ----- .
27341 SMIG-115 1.150 0.870 0.960 0.162 -0.798 ----- .
27391 TECO-115 1.150 0.870 0.967 0.677 -0.290 ----- .
27401 OZAT-115 1.150 0.870 0.956 0.429 -0.527 ----- .
VAR
21101 5NOV-U1 1 7.0 0.0 4.1 7.0 2.9 GENERATORS ON VAR LIMIT
                                     +
```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1313 : BRANCH 1073 ++BRANCH 1070

```
----- POST-CONTINGENCY RESULTS -----
SOLN  OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER  MM
NC-   3-1.79  0- 0.0  0-0.00  6-0.38  ( 107, 27) 20  5.61

OUTAGES FROM BUS      TO BUS      ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      36      133      0.27
27211 BERL-115 115 27341 SMIG-115 115 1      63      133      0.47
```

```
OVERLOAD FROM BUS      TO BUS      ID  BASE CONT  ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1      47  -83  1.66  1.66  1.66
24341 SMIG-46 46.0 27341 SMIG-115 115 2      47  -83  1.66  1.66  1.66
27181 15SE-115 115 27341 SMIG-115 115 1      40  262  2.32  1.97  1.97
```

```
* AREA      2 *
VOLTAGE  BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
          *-----*-----*-----*
24341 SMIG-46 4 1.150 0.870 1.012 0.488 -0.524 ----- .
24391 TECO-46 4 1.150 0.870 1.012 0.383 -0.629 ----- .
24401 OZAT-46 4 1.150 0.870 1.023 0.424 -0.599 ----- .
27341 SMIG-115 1.150 0.870 0.960 0.514 -0.446 ----- .
27391 TECO-115 1.150 0.870 0.967 0.389 -0.578 ----- .
27401 OZAT-115 1.150 0.870 0.956 0.422 -0.534 ----- .
VAR
21101 5NOV-U1 1 7.0 0.0 4.1 7.0 2.9 GENERATORS ON VAR LIMIT
                                     +
```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1320 : BRANCH 1084 ++BRANCH 1070

```
----- POST-CONTINGENCY RESULTS -----
SOLN  OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER  MM
-     3-1.09  0- 0.0  0-0.00  4-0.74  ( 74, 21) 3  0.08

OUTAGES FROM BUS      TO BUS      ID  BASE CASE  RATING-B  P.U.-B
27391 TECO-115 115 27401 OZAT-115 115 1      16      133      0.12
27211 BERL-115 115 27341 SMIG-115 115 1      63      133      0.47
```

```
OVERLOAD FROM BUS      TO BUS      ID  BASE CONT  ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1      47  -60  1.20  1.20  1.20
24341 SMIG-46 46.0 27341 SMIG-115 115 2      47  -60  1.20  1.20  1.20
27181 15SE-115 115 27341 SMIG-115 115 1      40  153  1.35  1.15  1.15
```

```
* AREA      2 *
VOLTAGE  BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
          *-----*-----*-----*
24341 SMIG-46 4 1.150 0.870 1.012 0.787 -0.225 ----- .
24401 OZAT-46 4 1.150 0.870 1.023 0.779 -0.244 ----- .
27341 SMIG-115 1.150 0.870 0.960 0.763 -0.197 ----- .
27401 OZAT-115 1.150 0.870 0.956 0.736 -0.220 ----- .
```


VAR

GENERATORS ON VAR LIMIT

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1337 : BRANCH 1075 ++BRANCH 1070

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 0-0.00 0- 0.0 0-0.00 1-0.85 (62, 20) 2 0.09

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27341 SMIG-115 115 27401 OZAT-115 115 1 10 133 0.07
27211 BERL-115 115 27341 SMIG-115 115 1 63 133 0.47

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
27341 SMIG-115 1.150 0.870 0.960 0.847 -0.113 . ----- .

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1533 : BRANCH 1073 ++BRANCH 1065

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 1-1.13 0- 0.0 0-0.00 6-0.76 (63, 20) 3 0.06

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1 36 133 0.27
27181 15SE-115 115 27341 SMIG-115 115 1 40 133 0.30

OVERLOAD FROM BUS TO BUS ID BASE CONT ---P.U. FLOWS---
27211 BERL-115 115 27341 SMIG-115 115 1 63 166 1.47 1.25 1.25

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
24341 SMIG-46 4 1.150 0.870 1.012 0.861 -0.151 . ----- .
24391 TECO-46 4 1.150 0.870 1.012 0.792 -0.220 . ----- .
24401 OZAT-46 4 1.150 0.870 1.023 0.829 -0.194 . ----- .
27341 SMIG-115 1.150 0.870 0.960 0.827 -0.133 . ----- .
27391 TECO-115 1.150 0.870 0.967 0.763 -0.204 . ----- .
27401 OZAT-115 1.150 0.870 0.956 0.781 -0.175 . ----- .

VAR GENERATORS ON VAR LIMIT

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1555 : BRANCH 1084 ++BRANCH 1065

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 0-0.00 0- 0.0 0-0.00 1-0.86 (57, 19) 3 0.03

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27391 TECO-115 115 27401 OZAT-115 115 1 16 133 0.12
27181 15SE-115 115 27341 SMIG-115 115 1 40 133 0.30

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
27401 OZAT-115 1.150 0.870 0.956 0.862 -0.094 . ----- .

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1578 : BRANCH 1090 ++BRANCH 1077

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
NC- 3-1.38 0- 0.0 0-0.00 20-0.60 (70, 24) 20 3.87

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27431 SMAR-115 115 27461 STOM-115 115 1 59 266 0.22
27361 SANT-115 115 27371 NEJA-115 115 1 42 266 0.16

OVERLOAD FROM BUS TO BUS ID BASE CONT ---P.U. FLOWS---
22421 NCUS-23 23.0 27421 NCUS-115 115 1 39 -57 1.14 1.14 1.14
22421 NCUS-23 23.0 27421 NCUS-115 115 2 39 -57 1.14 1.14 1.14
27411 SONS-115 115 27441 ATEO-115 115 1 69 202 1.79 1.52 1.52

* AREA 2 *
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. 0.7 0.9 1.1
----------*-----*

| | | | | | | | | | | |
|-------|----------|---|-------|-------|-------|-------|--------|-------|-------|---|
| 21131 | ACAJ-U1 | 1 | 1.150 | 0.870 | 0.980 | 0.867 | -0.113 | . | ----- | . |
| 21132 | ACAJ-U2 | 1 | 1.150 | 0.870 | 0.982 | 0.846 | -0.136 | . | ----- | . |
| 21139 | ACAJ-U6 | 1 | 1.150 | 0.870 | 0.990 | 0.846 | -0.144 | . | ----- | . |
| 21411 | CASA-U1 | 1 | 1.150 | 0.870 | 0.998 | 0.854 | -0.144 | . | ----- | . |
| 21441 | ATEO-GM | 1 | 1.150 | 0.870 | 1.018 | 0.764 | -0.254 | . | ----- | . |
| 22361 | SANT-23 | 2 | 1.150 | 0.870 | 1.022 | 0.695 | -0.327 | ----- | ----- | . |
| 22421 | NCUS-23 | 2 | 1.150 | 0.870 | 1.022 | 0.660 | -0.362 | ----- | ----- | . |
| 23441 | ATEO-34 | 3 | 1.150 | 0.870 | 1.024 | 0.750 | -0.274 | . | ----- | . |
| 24131 | ACAJ-46 | 4 | 1.150 | 0.870 | 1.008 | 0.853 | -0.155 | . | ----- | . |
| 24411 | SONS-46 | 4 | 1.150 | 0.870 | 0.998 | 0.854 | -0.144 | . | ----- | . |
| 24412 | CASSA | 4 | 1.150 | 0.870 | 0.998 | 0.854 | -0.144 | . | ----- | . |
| 24441 | ATEO-46 | 4 | 1.150 | 0.870 | 1.022 | 0.753 | -0.269 | . | ----- | . |
| 24461 | STOM-46 | 4 | 1.150 | 0.870 | 1.025 | 0.651 | -0.374 | ----- | ----- | . |
| 24471 | PEDR-46 | 4 | 1.150 | 0.870 | 1.021 | 0.630 | -0.391 | ----- | ----- | . |
| 27361 | SANT-115 | 1 | 1.150 | 0.870 | 0.975 | 0.679 | -0.296 | ----- | ----- | . |
| 27411 | SONS-115 | 1 | 1.150 | 0.870 | 1.005 | 0.864 | -0.141 | . | ----- | . |
| 27421 | NCUS-115 | 1 | 1.150 | 0.870 | 0.964 | 0.645 | -0.319 | ----- | ----- | . |
| 27441 | ATEO-115 | 1 | 1.150 | 0.870 | 0.983 | 0.722 | -0.261 | . | ----- | . |
| 27461 | STOM-115 | 1 | 1.150 | 0.870 | 0.963 | 0.619 | -0.344 | ----- | ----- | . |
| 27471 | PEDR-115 | 1 | 1.150 | 0.870 | 0.949 | 0.595 | -0.354 | ----- | ----- | . |

VAR GENERATORS ON VAR LIMIT
21161 AHUA-U1 1 18.0 -10.0 10.0 18.0 8.0 +
21162 AHUA-U2 1 18.0 -10.0 10.0 18.0 8.0 +

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.10 RATEB, V.COLLAPSE<0.50, VOLT>1.15, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 1597 : BRANCH 1090 ++BRANCH 1085

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 0-0.00 0- 0.0 0-0.00 1-0.87 (58, 19) 2 0.03

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27431 SMAR-115 115 27461 STOM-115 115 1 59 266 0.22
27411 SONS-115 115 27441 ATEO-115 115 1 69 133 0.52

* AREA 2 *
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. 0.7 0.9 1.1
----------*-----*

| | | | | | | | | | | |
|-------|----------|---|-------|-------|-------|-------|--------|---|-------|---|
| 27471 | PEDR-115 | 1 | 1.150 | 0.870 | 0.949 | 0.865 | -0.084 | . | ----- | . |
|-------|----------|---|-------|-------|-------|-------|--------|---|-------|---|

VAR GENERATORS ON VAR LIMIT
LIMIT

El resumen de los resultados se presenta en la siguiente tabla:

Cuadro 1 – Voltaje en p.u. de barras con violaciones de voltaje (0.87 p.u.).

| CONTINGENCIAS N-2 | Barras con Violaciones de Voltaje | | | | | | | |
|-----------------------|-----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--|
| | SMIG -115 | TECO -115 | OZAT -115 | STOM -115 | PEDR -115 | NCUS -115 | SANT -115 | |
| SRAF-TECO & BERL-U1 | | 0.866 | 0.883 | | | | | |
| SRAF-TECO & BERL-U2 | | 0.866 | 0.883 | | | | | |
| SRAF-TECO & 15SE-U1 | | 0.856 | 0.874 | | | | | |
| SRAF-TECO & BERL-U3 | | 0.865 | 0.882 | | | | | |
| SMAR-STOM & ACAJ-ATEO | | | | 0.866 | 0.850 | 0.886 | | |
| NCUS-ATEO & SRAF-TECO | | 0.868 | 0.886 | | | | | |
| BERL-SMIG & 15SE-SMIG | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | |
| SRAF-TECO & BERL-SMIG | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | |
| TECO-OZAT & BERL-SMIG | 0.763* | | 0.736* | | | | | |
| SMIG-OZAT & BERL-SMIG | 0.847 | | | | | | | |
| SRAF-TECO & 15SE-SMIG | 0.827* | 0.763* | 0.781* | | | | | |
| TECO-OZAT & 15SE-SMIG | | | 0.862 | | | | | |
| SMAR-STOM & SANT-NEJA | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | |
| SMAR-STOM & SONS-ATEO | | | | | 0.865 | | | |

Nota: (*) significa que también hay bajo voltaje en el secundario del transformador.

3.2.2. Caso B: Máxima transferencia Guatemala --> El Salvador 56 MW.

Archivo: MX_GE_56.raw (versión 26 convertida de MX_GE_56.sav)

Con el objeto de evitar el analizar los casos menos críticos, primeramente se hizo un análisis de la cantidad de casos de contingencias N-2 se producen en función del límites inferior de voltaje para el cual se considera un abatimiento del voltaje extremo:

| Límite inferior de voltaje en nodos (p.u.) | Número de casos con violación del límite inferior de voltaje | Número de casos con colapso de voltaje | Número de casos de no convergencia |
|--|--|--|------------------------------------|
| 0.90 | 187 | 1 | 1 |
| 0.89 | 185 | 1 | 1 |
| 0.88 | 75 | 1 | 1 |
| 0.87 | 12 | 2 | 1 |
| 0.86 | 5 | 2 | 1 |

Del cuadro anterior, se concluye que un caso de “No-convergencia” y que un caso de “colapso de voltaje”, son una constante en todos los escenarios posibles; y que además, como punto de partida, se analizarán los 14 casos de bajo voltaje con respecto a la violación de límite inferior de 0.87 p.u. de voltaje, cuyos resultados se muestran a continuación:

CONTINGENCY 259 : BRANCH 1073 ++BRANCH 1055

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      0-0.00   0- 0.0   0-0.00   1-0.87   ( 123, 31)  3   0.04

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29
27131 ACAJ-115 115 27441 ATEO-115 115 1      84      266      0.32

* AREA 2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
27391 TECO-115      1.100    0.870    0.966    0.867    -0.099    .        .        .
VAR                                          GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 272 : BRANCH 1073 ++BRANCH 1056

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      0-0.00   0- 0.0   0-0.00   1-0.87   ( 122, 31)  3   0.05

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29
27161 AHUA-115 115 27351 SANA-115 115 1      72      133      0.54

* AREA 2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
27391 TECO-115      1.100    0.870    0.966    0.869    -0.097    .        .        .
VAR                                          GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 284 : BRANCH 1070 ++BRANCH 1065

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
VC-    0-0.00   0- 0.0   0-0.00   6-0.03   ( 55, 19)  4  13.23

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27211 BERL-115 115 27341 SMIG-115 115 1      61      133      0.46
27181 15SE-115 115 27341 SMIG-115 115 1      38      133      0.29

* AREA 2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
24341 SMIG-46 4      1.100    0.870    1.011    0.028    -0.983    .        .        .
24391 TECO-46 4      1.100    0.870    1.010    0.719    -0.291    .        .        .
24401 OZAT-46 4      1.100    0.870    1.021    0.478    -0.543    .        .        .
27341 SMIG-115 1.100    0.870    0.959    0.191    -0.768    .        .        .
27391 TECO-115 1.100    0.870    0.966    0.696    -0.270    .        .        .
27401 OZAT-115 1.100    0.870    0.955    0.460    -0.495    .        .        .
VAR                                          GENERATORS ON VAR LIMIT
21101 5NOV-U1 13.8      7.0      0.0      4.3      7.0      2.7      +

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 285 : BRANCH 1073 ++BRANCH 1070

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
NC-    3-1.77   0- 0.0   0-0.00   6-0.43   ( 163, 44) 20   4.03

OUTAGES FROM BUS           TO BUS           ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29
27211 BERL-115 115 27341 SMIG-115 115 1      61      133      0.46

OVERLOAD FROM BUS           TO BUS           ID  BASE  CONT  ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1      47  -81  1.62  1.62  1.62
24341 SMIG-46 46.0 27341 SMIG-115 115 2      47  -81  1.62  1.62  1.62
27181 15SE-115 115 27341 SMIG-115 115 1      38  247  2.19  1.86  1.86

* AREA 2 *
VOLTAGE BUS NAME  MAX.  MIN.  BASE  CONT  DEV.  0.7  0.9  1.1
-----*-----*-----*-----*
24341 SMIG-46 4  1.100  0.870  1.011  0.525  -0.486  .
24391 TECO-46 4  1.100  0.870  1.010  0.429  -0.581  .
24401 OZAT-46 4  1.100  0.870  1.021  0.468  -0.553  .
27341 SMIG-115 1.100  0.870  0.959  0.543  -0.416  .
27391 TECO-115 1.100  0.870  0.966  0.430  -0.536  .
27401 OZAT-115 1.100  0.870  0.955  0.459  -0.496  .
VAR
21101 5NOV-U1 13.8      7.0  0.0  4.3  7.0  2.7  GENERATORS ON VAR LIMIT +

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD)= 1)

CONTINGENCY 323 : BRANCH 1073 ++UNIT 303

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      0-0.00   0- 0.0   0-0.00   2-0.85   ( 121, 31) 3   0.04

OUTAGES FROM BUS           TO BUS           ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29
21181 15SE-U1 13.8      1      43      80

* AREA 2 *
VOLTAGE BUS NAME  MAX.  MIN.  BASE  CONT  DEV.  0.7  0.9  1.1
-----*-----*-----*-----*
27391 TECO-115 1.100  0.870  0.966  0.853  -0.113  .
27401 OZAT-115 1.100  0.870  0.955  0.869  -0.086  .
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD)= 1)

CONTINGENCY 329 : BRANCH 1086 ++BRANCH 1073

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      0-0.00   0- 0.0   0-0.00   1-0.87   ( 122, 31) 3   0.07

OUTAGES FROM BUS           TO BUS           ID  BASE CASE  RATING-B  P.U.-B
27421 NCUS-115 115 27441 ATEO-115 115 1      102     266     0.38
27321 SRAF-115 115 27391 TECO-115 115 1      39      133     0.29

* AREA 2 *
VOLTAGE BUS NAME  MAX.  MIN.  BASE  CONT  DEV.  0.7  0.9  1.1
-----*-----*-----*-----*
27391 TECO-115 1.100  0.870  0.966  0.865  -0.101  .
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD)= 1)

CONTINGENCY 330 : BRANCH 1073 ++BRANCH 1065

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
-          3-1.20    0- 0.0    0-0.00    6-0.75  ( 122, 31)  4    0.06

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29
27181 15SE-115 115 27341 SMIG-115 115 1      38      133      0.29

OVERLOAD FROM BUS          TO BUS          ID  BASE CONT  ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1      47     -55      1.10  1.10  1.10
24341 SMIG-46 46.0 27341 SMIG-115 115 2      47     -55      1.10  1.10  1.10
27211 BERL-115 115 27341 SMIG-115 115 1      61     168      1.49  1.26  1.26

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
          *-----*-----*-----*-----*
24341 SMIG-46 4 1.100  0.870  1.011  0.851  -0.160  .          .          .
24391 TECO-46 4 1.100  0.870  1.010  0.781  -0.229  .          .          .
24401 OZAT-46 4 1.100  0.870  1.021  0.818  -0.203  .          .          .
27341 SMIG-115 1.100  0.870  0.959  0.818  -0.141  .          .          .
27391 TECO-115 1.100  0.870  0.966  0.753  -0.213  .          .          .
27401 OZAT-115 1.100  0.870  0.955  0.771  -0.184  .          .          .
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 332 : BRANCH 1073 ++BRANCH 1071

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
-          0-0.00    0- 0.0    0-0.00    1-0.87  ( 118, 30)  3    0.04

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29
27301 SOYA-115 115 27371 NEJA-115 115 1      102     266      0.38

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
          *-----*-----*-----*
27391 TECO-115 1.100  0.870  0.966  0.868  -0.098  .          .          .
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 334 : BRANCH 1073 ++BRANCH 1050

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
-          0-0.00    0- 0.0    0-0.00    1-0.87  ( 117, 30)  2    0.03

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29
27101 5NOV-115 115 27321 SRAF-115 115 1      61      266      0.23

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
          *-----*-----*-----*
27391 TECO-115 1.100  0.870  0.966  0.867  -0.099  .          .          .
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 338 : BRANCH 1080 ++BRANCH 1073

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
-          0-0.00   0- 0.0   0-0.00   1-0.87   ( 116, 29)  2   0.05

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27371 NEJA-115 115 27431 SMAR-115 115 1      59      266      0.22
27321 SRAF-115 115 27391 TECO-115 115 1      39      133      0.29

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
27391 TECO-115      1.100    0.870    0.966    0.869    -0.097    *-----*-----*-----*
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 442 : BRANCH 1090 ++BRANCH 1077

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
VC-       0-0.00   0- 0.0   0-0.00   12-0.70  ( 126, 34)  2  16.88

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27431 SMAR-115 115 27461 STOM-115 115 1      57      266      0.21
27361 SANT-115 115 27371 NEJA-115 115 1      43      266      0.16

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
21441 ATEO-GM 1 1.100    0.870    1.018    0.841    -0.177    .-----*-----*
22361 SANT-23 2 1.100    0.870    1.020    0.794    -0.226    .-----*-----*
22421 NCUS-23 2 1.100    0.870    1.020    0.769    -0.251    .-----*-----*
23441 ATEO-34 3 1.100    0.870    1.021    0.831    -0.190    .-----*-----*
24441 ATEO-46 4 1.100    0.870    1.021    0.835    -0.186    .-----*-----*
24461 STOM-46 4 1.100    0.870    1.024    0.758    -0.266    .-----*-----*
24471 PEDR-46 4 1.100    0.870    1.020    0.743    -0.277    .-----*-----*
27361 SANT-115 1.100    0.870    0.973    0.767    -0.206    .-----*-----*
27421 NCUS-115 1.100    0.870    0.962    0.739    -0.223    .-----*-----*
27441 ATEO-115 1.100    0.870    0.980    0.800    -0.180    .-----*-----*
27461 STOM-115 1.100    0.870    0.962    0.717    -0.245    .-----*-----*
27471 PEDR-115 1.100    0.870    0.948    0.697    -0.251    .-----*-----*
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 568 : BRANCH 1084 ++BRANCH 1070

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
-          3-1.14   0- 0.0   0-0.00   4-0.73   ( 134, 34)  4   0.02

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27391 TECO-115 115 27401 OZAT-115 115 1      19      133      0.14
27211 BERL-115 115 27341 SMIG-115 115 1      61      133      0.46

OVERLOAD FROM BUS          TO BUS          ID  BASE CONT  ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1      47  -60  1.20  1.20  1.20
24341 SMIG-46 46.0 27341 SMIG-115 115 2      47  -60  1.20  1.20  1.20
27181 15SE-115 115 27341 SMIG-115 115 1      38  154  1.36  1.16  1.16

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
24341 SMIG-46 4 1.100    0.870    1.011    0.779    -0.232    .-----*-----*
24401 OZAT-46 4 1.100    0.870    1.021    0.771    -0.250    .-----*-----*
27341 SMIG-115 1.100    0.870    0.959    0.756    -0.203    .-----*-----*
27401 OZAT-115 1.100    0.870    0.955    0.729    -0.226    .-----*-----*
VAR
GENERATORS ON VAR LIMIT

```


S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 570 : BRANCH 1084 ++BRANCH 1065

| ----- POST-CONTINGENCY RESULTS ----- | | | | | | | | | |
|--------------------------------------|----------------|--------------------|-----------|-----------|------------|--------|-------------------------|-------|-----|
| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING GEN | ITER | MM | | |
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.86 | (115, 29) | 3 | 0.03 | | |
| OUTAGES | FROM BUS | TO BUS | ID | BASE CASE | RATING-B | P.U.-B | | | |
| | 27391 TECO-115 | 115 27401 OZAT-115 | 115 1 | 19 | 133 | 0.14 | | | |
| | 27181 15SE-115 | 115 27341 SMIG-115 | 115 1 | 38 | 133 | 0.29 | | | |
| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----*-----*-----* | | |
| | 27401 OZAT-115 | 1.100 | 0.870 | 0.955 | 0.859 | -0.096 | . | ----- | . |
| VAR | | | | | | | GENERATORS ON VAR LIMIT | | |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPE<0.50, VOLT>1.10, VOLT<0.87, BUSES/ISLD>= 1)

CONTINGENCY 585 : BRANCH 1075 ++BRANCH 1070

| ----- POST-CONTINGENCY RESULTS ----- | | | | | | | | | |
|--------------------------------------|----------------|---------------------|-----------|-----------|------------|------------------|-------------------------|-------|-----|
| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING GEN | ITER | MM | | |
| - | 2-1.01 | 0- 0.0 | 0-0.00 | 1-0.84 | (121, 31) | 3 | 0.10 | | |
| OUTAGES | FROM BUS | TO BUS | ID | BASE CASE | RATING-B | P.U.-B | | | |
| | 27341 SMIG-115 | 115 27401 OZAT-115 | 115 1 | 7 | 133 | 0.05 | | | |
| | 27211 BERL-115 | 115 27341 SMIG-115 | 115 1 | 61 | 133 | 0.46 | | | |
| OVERLOAD | FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- | | | |
| | 24341 SMIG-46 | 46.0 27341 SMIG-115 | 115 1 | 47 | -53 | 1.06 1.06 1.06 | | | |
| | 24341 SMIG-46 | 46.0 27341 SMIG-115 | 115 2 | 47 | -53 | 1.06 1.06 1.06 | | | |
| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----*-----*-----* | | |
| | 27341 SMIG-115 | 1.100 | 0.870 | 0.959 | 0.843 | -0.116 | . | ----- | . |
| VAR | | | | | | | GENERATORS ON VAR LIMIT | | |

El resumen de los resultados se presenta en la siguiente tabla:

Cuadro 1 – Voltaje en p.u. de barras con violaciones de voltaje (0.87 p.u.).

| CONTINGENCIAS N-2 GUAT->ELSA 56 MW | Barras con Violaciones de Voltaje | | | | | | |
|---------------------------------------|-----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | SMIG -115 | TECO -115 | OZAT -115 | STOM -115 | PEDR -115 | NCUS -115 | SANT -115 |
| SRAF-TECO & 15SE-U1 | | 0.853 | 0.869 | | | | |
| SMAR-STOM & ACAJ-ATEO | | | | 0.863 | 0.846 | | |
| SRAF-TECO & ACAJ-ATEO | | 0.867 | | | | | |
| SRAF-TECO & AHUA-SANA | | 0.869 | | | | | |
| NCUS-ATEO & SRAF-TECO | | 0.865 | | | | | |
| BERL-SMIG & 15SE-SMIG | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. |
| SRAF-TECO & BERL-SMIG | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. |
| TECO-OZAT & BERL-SMIG | 0.756* | | 0.729* | | | | |
| SMIG-OZAT & BERL-SMIG | 0.843 | | | | | | |

| | | | | | | | |
|-----------------------|--------|--------|--------|------|------|------|------|
| SRAF-TECO & 15SE-SMIG | 0.818* | 0.753* | 0.771* | | | | |
| SRAF-TECO & SOYA-NEJA | | 0.868 | | | | | |
| SRAF-TECO & 5NOV-SRAF | | 0.867 | | | | | |
| NEJA-SMAR & SRAF-TECO | | 0.869 | | | | | |
| TECO-OZAT & 15SE-SMIG | | | 0.859 | | | | |
| SMAR-STOM & SANT-NEJA | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. |

Nota: (*) significa que también hay bajo voltaje en el secundario del transformador.

3.2.3. Caso C: Máxima transferencia El Salvador --> Guatemala 90 MW

Archivo: MX_EG_90.raw (versión 26 convertida de MX_EG_90.sav)

Con el objeto de evitar el analizar los casos menos críticos, primeramente se hizo un análisis de la cantidad de casos de contingencias N-2 se producen en función del límites inferior de voltaje para el cual se considera un abatimiento del voltaje extremo:

| Límite inferior de voltaje en nodos (p.u.) | Número de casos con violación del límite inferior de voltaje | Número de casos con colapso de voltaje | Número de casos de no convergencia |
|--|--|--|------------------------------------|
| 0.90 | 71 | 2 | 0 |
| 0.89 | 4 | 2 | 0 |
| 0.88 | 3 | 2 | 0 |
| 0.87 | 3 | 2 | 0 |
| 0.86 | 2 | 2 | 0 |

Del cuadro anterior, se concluye que un caso de “No-convergencia” y que un caso de “colapso de voltaje”, son una constante en todos los escenarios posibles; y que además, como punto de partida, se analizarán los 14 casos de bajo voltaje con respecto a la violación de límite inferior de 0.87 p.u. de voltaje, cuyos resultados se muestran a continuación:

```

*** CONTINGENCY RESULTS SUMMARY ***

TOTAL NO. OF CONTINGENCIES TESTED      =    726
I.   CONVERGED CONTINGENCIES            =    724
II.  VOLTAGE COLLAPSE CONTINGENCIES    =     2
III. NOT CONVERGED CONTINGENCIES       =     0

*** FAILURE SUMMARY ***
FAILURE CRITERIA                        NO. OF WORST CASE
                                         FAILURES INDEX  VALUE
-----
I.   CONVERGED ( 724 CONTINGENCIES) :
      AT LEAST ( 1) BUSES PER ISLAND      0      0 ( 0)
      OVERLOAD ABOVE (1.05) PU OF RATING (B) 6     296 ( 2.74)
      CHANGE IN FLOW ABOVE (999.0%)        0      0 ( 0.0)
      BUS VOLTAGE ABOVE ( 1.10) P.U.       0      0 ( 0.00)
      BUS VOLTAGE BELOW ( 0.89) P.U.       4     407 ( 0.67)
      SUBTOTAL                             8
II.  VOLTAGE COLLAPSE:                    2
III. NOT-CONVERGED (MM > 0.10)          0

TOTAL FAILED CONTINGENCIES :             10
(OOUT OF 726 CONTINGENCIES TESTED)

```

Los resultados indican lo siguiente:

- El TPLAN realizó 726 contingencias de líneas de transmisión y de generación.
- 4 casos de contingencias presentan violación del límite inferior de la banda de emergencia de voltaje (0.89 p.u.).
- Hay 6 casos de violación por sobrecarga de líneas de transmisión, los cuales no son objeto del presente estudio.
- Hay 2 casos de colapso de voltaje y 0 casos de no convergencia en la solución de flujo de potencia.

Un resumen detallado de los casos de bajo voltaje se muestra a continuación:

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 309 : BRANCH 1070 ++BRANCH 1065

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING GEN | ITER | MM |
|------|----------|-----------|-----------|----------|-----------|------|------|
| VC- | 5-1.81 | 0- 0.0 | 0-0.00 | 6-0.00 | (26, 28) | 7 | 0.10 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|--------------------|-----|------|------|----------|--------|
| 27211 | BERL-115 | 115 27341 SMIG-115 | 115 | 1 | 61 | 133 | 0.46 |
| 27181 | 15SE-115 | 115 27341 SMIG-115 | 115 | 1 | 38 | 133 | 0.29 |

| OVERLOAD FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- |
|-------------------|---------------------|-----|------|--------|------------------|
| 24341 SMIG-46 | 46.0 27341 SMIG-115 | 115 | 1 | 44 95 | 1.90 1.90 1.90 |
| 24341 SMIG-46 | 46.0 27341 SMIG-115 | 115 | 2 | 44 95 | 1.90 1.90 1.90 |
| 27321 SRAF-115 | 115 27391 TECO-115 | 115 | 1 | 32 225 | 1.99 1.69 1.69 |
| 27341 SMIG-115 | 115 27401 OZAT-115 | 115 | 1 | 12 190 | 1.68 1.43 1.43 |
| 27391 TECO-115 | 115 27401 OZAT-115 | 115 | 1 | 14 215 | 1.90 1.62 1.62 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|-----------|-------|-------|-------|-------|--------|-------------------------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 24341 | SMIG-46 4 | 1.100 | 0.890 | 1.047 | 0.000 | -1.047 | ----- | . | . |
| 24391 | TECO-46 4 | 1.100 | 0.890 | 1.057 | 0.725 | -0.332 | ----- | . | . |
| 24401 | OZAT-46 4 | 1.100 | 0.890 | 1.031 | 0.434 | -0.597 | ----- | . | . |
| 27341 | SMIG-115 | 1.100 | 0.890 | 0.980 | 0.173 | -0.807 | ----- | . | . |
| 27391 | TECO-115 | 1.100 | 0.890 | 0.986 | 0.686 | -0.300 | ----- | . | . |
| 27401 | OZAT-115 | 1.100 | 0.890 | 0.976 | 0.431 | -0.545 | ----- | . | . |
| VAR | | | | | | | GENERATORS ON VAR LIMIT | | |
| 21101 | 5NOV-U1 1 | 7.0 | 0.0 | 2.9 | 7.0 | 4.1 | | | + |
| 21104 | 5NOV-U451 | 20.0 | -22.0 | 9.4 | 20.0 | 10.6 | | | + |
| 21161 | AHUA-U1 1 | 18.0 | -10.0 | 12.3 | 18.0 | 5.7 | | | + |
| 21162 | AHUA-U2 1 | 18.0 | -10.0 | 12.3 | 18.0 | 5.7 | | | + |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 382 : BRANCH 1090 ++BRANCH 1055

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING GEN | ITER | MM |
|------|----------|-----------|-----------|----------|-----------|------|------|
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 3-0.86 | (72, 30) | 4 | 0.06 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|--------------------|-----|------|------|----------|--------|
| 27431 | SMAR-115 | 115 27461 STOM-115 | 115 | 1 | 74 | 266 | 0.28 |
| 27131 | ACAJ-115 | 115 27441 ATEO-115 | 115 | 1 | 72 | 266 | 0.27 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|--------------|-------|-------|-------|-------|--------|---------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 27421 | NCUS-115 115 | 1.100 | 0.890 | 0.965 | 0.889 | -0.076 | . | ----- | . |

| | | | | | | | | | | |
|-------|----------|-----|-------|-------|-------|-------|--------|---|-------|---|
| 27461 | STOM-115 | 115 | 1.100 | 0.890 | 0.969 | 0.876 | -0.093 | . | ----- | . |
| 27471 | PEDR-115 | 115 | 1.100 | 0.890 | 0.955 | 0.860 | -0.095 | . | ----- | . |

VAR
LIMIT

GENERATORS ON VAR

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 383 : BRANCH 1090 ++BRANCH 1077

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
VC- 0-0.00 0- 0.0 0-0.00 14-0.67 (88, 37) 3 12.63

| | | | | | | | |
|---------|----------|-----------|----------|------|------|----------|----------|
| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
| 27431 | SMAR-115 | 115 27461 | STOM-115 | 115 | 1 | 74 | 266 0.28 |
| 27361 | SANT-115 | 115 27371 | NEJA-115 | 115 | 1 | 67 | 266 0.25 |

| | | | | | | | | | |
|---------|----------|-------|-------|-------|-------|--------|---------|---------|---------|
| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 21132 | ACAJ-U2 | 1 | 1.100 | 0.890 | 0.982 | 0.887 | -0.095 | . | ----- |
| 21139 | ACAJ-U6 | 1 | 1.100 | 0.890 | 0.990 | 0.887 | -0.103 | . | ----- |
| 21441 | ATEO-GM | 1 | 1.100 | 0.890 | 1.018 | 0.820 | -0.198 | . | ----- |
| 22361 | SANT-23 | 2 | 1.100 | 0.890 | 1.014 | 0.754 | -0.260 | . | ----- |
| 22421 | NCUS-23 | 2 | 1.100 | 0.890 | 1.011 | 0.728 | -0.283 | . | ----- |
| 23441 | ATEO-34 | 3 | 1.100 | 0.890 | 1.025 | 0.809 | -0.216 | . | ----- |
| 24441 | ATEO-46 | 4 | 1.100 | 0.890 | 1.023 | 0.812 | -0.211 | . | ----- |
| 24461 | STOM-46 | 4 | 1.100 | 0.890 | 1.039 | 0.736 | -0.303 | . | ----- |
| 24471 | PEDR-46 | 4 | 1.100 | 0.890 | 1.027 | 0.713 | -0.314 | . | ----- |
| 27361 | SANT-115 | 1.100 | 0.890 | 0.975 | 0.737 | -0.238 | . | ----- | |
| 27421 | NCUS-115 | 1.100 | 0.890 | 0.965 | 0.711 | -0.254 | . | ----- | |
| 27441 | ATEO-115 | 1.100 | 0.890 | 0.985 | 0.779 | -0.206 | . | ----- | |
| 27461 | STOM-115 | 1.100 | 0.890 | 0.969 | 0.691 | -0.278 | . | ----- | |
| 27471 | PEDR-115 | 1.100 | 0.890 | 0.955 | 0.670 | -0.285 | . | ----- | |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 407 : BRANCH 1073 ++BRANCH 1070

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 3-1.34 0- 0.0 0-0.00 6-0.67 (95, 33) 5 0.04

| | | | | | | | |
|---------|----------|-----------|----------|------|------|----------|----------|
| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
| 27321 | SRAF-115 | 115 27391 | TECO-115 | 115 | 1 | 32 | 133 0.24 |
| 27211 | BERL-115 | 115 27341 | SMIG-115 | 115 | 1 | 61 | 133 0.46 |

| | | | | | |
|-------------------|----------|------------|----------|------|-------------------------|
| OVERLOAD FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- |
| 24341 | SMIG-46 | 46.0 27341 | SMIG-115 | 115 | 1 44 -61 1.22 1.22 1.22 |
| 24341 | SMIG-46 | 46.0 27341 | SMIG-115 | 115 | 2 44 -61 1.22 1.22 1.22 |
| 27181 | 15SE-115 | 115 27341 | SMIG-115 | 115 | 1 38 187 1.65 1.41 1.41 |

| | | | | | | | | | |
|---------|----------|-------|-------|-------|-------|--------|---------|---------|---------|
| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 24341 | SMIG-46 | 4 | 1.100 | 0.890 | 1.047 | 0.752 | -0.295 | . | ----- |
| 24391 | TECO-46 | 4 | 1.100 | 0.890 | 1.057 | 0.703 | -0.354 | . | ----- |
| 24401 | OZAT-46 | 4 | 1.100 | 0.890 | 1.031 | 0.704 | -0.327 | . | ----- |
| 27341 | SMIG-115 | 1.100 | 0.890 | 0.980 | 0.725 | -0.255 | . | ----- | |
| 27391 | TECO-115 | 1.100 | 0.890 | 0.986 | 0.666 | -0.320 | . | ----- | |
| 27401 | OZAT-115 | 1.100 | 0.890 | 0.976 | 0.678 | -0.298 | . | ----- | |

VAR

GENERATORS ON VAR LIMIT

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 564 : BRANCH 1075 ++BRANCH 1070

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      0-0.00   0- 0.0   0-0.00   1-0.89   ( 71, 30)  3   0.02

OUTAGES FROM BUS      TO BUS      ID  BASE CASE  RATING-B  P.U.-B
27341 SMIG-115 115 27401 OZAT-115 115 1      12      133      0.09
27211 BERL-115 115 27341 SMIG-115 115 1      61      133      0.46

* AREA 2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
27341 SMIG-115      1.100    0.890    0.980    0.886    -0.094    .      .      .
VAR
GENERATORS ON VAR LIMIT

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLVD> 1.05 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD=>= 1)

CONTINGENCY 623 : BRANCH 1084 ++BRANCH 1070

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
-      2-1.01   0- 0.0   0-0.00   4-0.80   ( 78, 31)  3   0.03

OUTAGES FROM BUS      TO BUS      ID  BASE CASE  RATING-B  P.U.-B
27391 TECO-115 115 27401 OZAT-115 115 1      14      133      0.11
27211 BERL-115 115 27341 SMIG-115 115 1      61      133      0.46

OVERLOAD FROM BUS      TO BUS      ID  BASE CONT  ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1      44  -53  1.06 1.06 1.06
24341 SMIG-46 46.0 27341 SMIG-115 115 2      44  -53  1.06 1.06 1.06

* AREA 2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
24341 SMIG-46 4      1.100    0.890    1.047    0.862    -0.185    .      .      .
24401 OZAT-46 4      1.100    0.890    1.031    0.834    -0.197    .      .      .
27341 SMIG-115      1.100    0.890    0.980    0.819    -0.161    .      .      .
27401 OZAT-115      1.100    0.890    0.976    0.795    -0.181    .      .      .
VAR
GENERATORS ON VAR LIMIT

```

El resumen de los resultados se presenta en la siguiente tabla:

Cuadro 1 – Voltaje en p.u. de barras con violaciones de voltaje (0.89 p.u.).

| CONTINGENCIAS N-2 ELSA->GUAT 90 MW | Barras con Violaciones de Voltaje | | | | | | |
|---------------------------------------|-----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | SMIG -115 | TECO -115 | OZAT -115 | STOM -115 | PEDR -115 | NCUS -115 | SANT -115 |
| SMAR-STOM & ACAJ-ATEO | | | | 0.876 | 0.860 | 0.889 | |
| BERL-SMIG & 15SE-SMIG | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. |
| SRAF-TECO & BERL-SMIG | 0.725* | 0.666* | 0.678* | | | | |
| TECO-OZAT & BERL-SMIG | 0.819* | | 0.795* | | | | |
| SMIG-OZAT & BERL-SMIG | 0.886 | | | | | | |
| SMAR-STOM & SANT-NEJA | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. |

Nota: (*) significa que también hay bajo voltaje en el secundario del transformador.

3.2.4. Caso D: Máxima transferencia Honduras --> El Salvador 104 MW

Archivo: MX_HE_104.raw (versión 26 convertida de MX_HE_104.sav)

Con el objeto de evitar el analizar los casos menos críticos, primeramente se hizo un análisis de la cantidad de casos de contingencias N-2 que se producen en función del límites inferior de voltaje para el cual se considera un abatimiento del voltaje extremo:

| Límite inferior de voltaje en nodos (p.u.) | Número de casos con violación del límite inferior de voltaje | Número de casos con colapso de voltaje | Número de casos de no convergencia |
|--|--|--|------------------------------------|
| 0.90 | 25 | 1 | 2 |
| 0.89 | 11 | 1 | 2 |
| 0.88 | 4 | 1 | 2 |
| 0.87 | 2 | 1 | 2 |
| 0.86 | 2 | 1 | 2 |

Del cuadro anterior, se concluye que dos casos de “No-convergencia” y que un caso de “colapso de voltaje”, son una constante en todos los escenarios posibles; y que además, como punto de partida, se analizarán los 7 casos de bajo voltaje con respecto a la violación de límite inferior de 0.89 p.u. de voltaje, cuyos resultados se muestran a continuación:

```

*** CONTINGENCY RESULTS SUMMARY ***

TOTAL NO. OF CONTINGENCIES TESTED      =    701
I.   CONVERGED CONTINGENCIES            =    698
II.  VOLTAGE COLLAPSE CONTINGENCIES     =     1
III. NOT CONVERGED CONTINGENCIES        =     2

*** FAILURE SUMMARY ***

FAILURE CRITERIA                        NO. OF WORST CASE
-----                                FAILURES INDEX VALUE
I.   CONVERGED ( 698 CONTINGENCIES) :

AT LEAST ( 1) BUSES PER ISLAND          0      0 ( 0)
OVERLOAD ABOVE (1.00) PU OF RATING (B)  13     251 ( 1.56)
CHANGE IN FLOW ABOVE (999.0%)           0      0 ( 0.0)
BUS VOLTAGE ABOVE ( 1.10) P.U.          0      0 ( 0.00)
BUS VOLTAGE BELOW ( 0.89) P.U.         11     629 ( 0.77)
SUBTOTAL                                20
II.  VOLTAGE COLLAPSE:                   1
III. NOT-CONVERGED (MM > 0.10)          2

TOTAL FAILED CONTINGENCIES :             23
(OFT OF 701 CONTINGENCIES TESTED)

```

Los resultados indican lo siguiente:

- El TPLAN realizó 701 contingencias de líneas de transmisión y de generación.
- 11 casos de contingencias presentan violación del límite inferior de la banda de emergencia de voltaje (0.89 p.u.).
- Hay 13 casos de violación por sobrecarga de líneas de transmisión, los cuales no son objeto del presente estudio.
- Hay casos 1 caso de colapso de voltaje y 2 casos de no convergencia en la solución de flujo de potencia.

Un resumen detallado de los casos de bajo voltaje se muestra a continuación:

SUMMARY OF FAILED CONTINGENCIES
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 106 : BRANCH 1070 ++UNIT 301

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 0-0.00 0- 0.0 0-0.00 1-0.89 (65, 36) 3 0.02

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27211 BERL-115 115 27341 SMIG-115 115 1 65 133 0.49
21171 CGRA-U1 13.8 1 68 68

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
27341 SMIG-115 1.100 0.890 0.972 0.888 -0.084 . - - .
VAR GENERATORS ON VAR LIMIT
21101 5NOV-U1 1 7.0 0.0 3.8 7.0 3.2 +

SUMMARY OF FAILED CONTINGENCIES
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 220 : BRANCH 1070 ++UNIT 303

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 0-0.00 0- 0.0 0-0.00 1-0.88 (62, 36) 3 0.06

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27211 BERL-115 115 27341 SMIG-115 115 1 65 133 0.49
21181 15SE-U1 13.8 1 80 80

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
27341 SMIG-115 1.100 0.890 0.972 0.883 -0.089 . - - .

SUMMARY OF FAILED CONTINGENCIES
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 255 : BRANCH 1090 ++BRANCH 1055

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 1-1.14 0- 0.0 0-0.00 3-0.87 (63, 36) 3 0.05

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27431 SMAR-115 115 27461 STOM-115 115 1 78 266 0.29
27131 ACAJ-115 115 27441 ATEO-115 115 1 86 266 0.32

OVERLOAD FROM BUS TO BUS ID BASE CONT ---P.U. FLOWS---
27411 SONS-115 115 27441 ATEO-115 115 1 70 152 1.35 1.14 1.14

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
27421 NCUS-115 1.100 0.890 0.965 0.887 -0.078 . - - .
27461 STOM-115 1.100 0.890 0.969 0.878 -0.091 . - - .
27471 PEDR-115 1.100 0.890 0.964 0.871 -0.093 . - - .

SUMMARY OF FAILED CONTINGENCIES
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 256 : BRANCH 1077 ++BRANCH 1055

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
-          1-1.28    0- 0.0    0-0.00    1-0.88    ( 63, 36)  3    0.03

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27361 SANT-115 115 27371 NEJA-115 115 1      68      266      0.26
27131 ACAJ-115 115 27441 ATEO-115 115 1      86      266      0.32

OVERLOAD FROM BUS          TO BUS          ID  BASE CONT  ---P.U. FLOWS---
27411 SONS-115 115 27441 ATEO-115 115 1      70    170    1.50 1.28 1.28

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
27361 SANT-115      1.100    0.890    0.973    0.878    -0.095    .      -----    .

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD=>= 1)

CONTINGENCY 264 : BRANCH 1070 ++BRANCH 1065

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
NC-       4-1.41    0- 0.0    0-0.00    6-0.41    ( 49, 35) 20    3.99

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27211 BERL-115 115 27341 SMIG-115 115 1      65      133      0.49
27181 15SE-115 115 27341 SMIG-115 115 1      42      133      0.31

OVERLOAD FROM BUS          TO BUS          ID  BASE CONT  ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1      44    -67    1.34 1.34 1.34
24341 SMIG-46 46.0 27341 SMIG-115 115 2      44    -67    1.34 1.34 1.34
27321 SRAF-115 115 27391 TECO-115 115 1      24    187    1.65 1.41 1.41
27391 TECO-115 115 27401 OZAT-115 115 1      11    170    1.50 1.28 1.28

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
24341 SMIG-46 4      1.100    0.890    1.010    0.412    -0.598    -----    .
24391 TECO-46 4      1.100    0.890    1.011    0.773    -0.238    .      -----    .
24401 OZAT-46 4      1.100    0.890    1.023    0.602    -0.421    -----    .
27341 SMIG-115 115 1.100    0.890    0.972    0.438    -0.534    -----    .
27391 TECO-115 115 1.100    0.890    0.980    0.757    -0.223    .      -----    .
27401 OZAT-115 115 1.100    0.890    0.969    0.585    -0.384    -----    .

VAR
21101 5NOV-U1 1      7.0      0.0      3.8      7.0      3.2      GENERATORS ON VAR LIMIT
21372 NEJA-G2 1      23.0     -23.3    14.4     23.0     8.6      +

```

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD=>= 1)

CONTINGENCY 268 : BRANCH 1073 ++BRANCH 1070

```

----- POST-CONTINGENCY RESULTS -----
SOLN      OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER      MM
VC-       6-2.59    0- 0.0    0-0.00    46-0.00   ( 50, 41) 11    0.05

OUTAGES FROM BUS          TO BUS          ID  BASE CASE  RATING-B  P.U.-B
27321 SRAF-115 115 27391 TECO-115 115 1      24      133      0.18
27211 BERL-115 115 27341 SMIG-115 115 1      65      133      0.49

OVERLOAD FROM BUS          TO BUS          ID  BASE CONT  ---P.U. FLOWS---
21181 15SE-U1 13.8 27181 15SE-115 115 1      86    110    1.10 1.10 1.10
21371 NEJA-G1 13.8 27371 NEJA-115 115 1      49    72    1.11 1.11 1.11
24341 SMIG-46 46.0 27341 SMIG-115 115 1      44    125    2.50 2.50 2.50
24341 SMIG-46 46.0 27341 SMIG-115 115 2      44    125    2.50 2.50 2.50
24401 OZAT-46 46.0 27401 OZAT-115 115 1      25    59    1.18 1.18 1.18
27181 15SE-115 115 27341 SMIG-115 115 1      42    344    3.04 2.59 2.59

* AREA      2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
27321 SRAF-115 115 1.100    0.890    0.989    0.843    -0.146    .      -----    .
27341 SMIG-115 115 1.100    0.890    0.972    0.240    -0.732    -----    .

```


| | | | | | | | | | |
|-------|----------|-------|-------|-------|-------|--------|---|-------|---|
| 27361 | SANT-115 | 1.100 | 0.890 | 0.973 | 0.852 | -0.121 | . | ----- | . |
| 27371 | NEJA-115 | 1.100 | 0.890 | 0.978 | 0.855 | -0.123 | . | ----- | . |
| 27381 | OPIC-115 | 1.100 | 0.890 | 0.976 | 0.875 | -0.101 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 289 : BRANCH 1090 ++BRANCH 1077

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING GEN | ITER | MM |
|------|----------|-----------|-----------|----------|-----------|------|-------|
| NC- | 0-0.00 | 0- 0.0 | 8-1.14 | 0-0.00 | (40, 34) | 20 | 81.19 |

| OUTAGES FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|--------------------|--------------------|----|------|------|----------|--------|
| 27431 SMAR-115 115 | 27461 STOM-115 115 | 1 | 78 | 266 | 0.29 | |
| 27361 SANT-115 115 | 27371 NEJA-115 115 | 1 | 68 | 266 | 0.26 | |

* AREA 2 *

| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | 0.7 | 0.9 | 1.1 |
|---------|-----------|-------|-------|-------|-------|-------|-----|-----|-------|
| 21135 | ACAJ-U5 1 | 1.100 | 0.890 | 1.000 | 1.110 | 0.110 | . | | +++++ |
| 22361 | SANT-23 2 | 1.100 | 0.890 | 1.020 | 1.116 | 0.096 | . | | ++++ |
| 22421 | NCUS-23 2 | 1.100 | 0.890 | 1.023 | 1.136 | 0.113 | . | | ++++ |
| 23131 | ACAJ-34 3 | 1.100 | 0.890 | 1.034 | 1.123 | 0.089 | . | | ++++ |
| 23441 | ATEO-34 3 | 1.100 | 0.890 | 1.018 | 1.108 | 0.090 | . | | ++++ |
| 24461 | STOM-46 4 | 1.100 | 0.890 | 1.013 | 1.112 | 0.099 | . | | ++++ |
| 24471 | PEDR-46 4 | 1.100 | 0.890 | 1.014 | 1.123 | 0.109 | . | | ++++ |
| 27131 | ACAJ-115 | 1.100 | 0.890 | 1.024 | 1.111 | 0.087 | . | | ++++ |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 319 : BRANCH 1073 ++BRANCH 1065

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING GEN | ITER | MM |
|------|----------|-----------|-----------|----------|-----------|------|------|
| - | 1-1.11 | 0- 0.0 | 0-0.00 | 4-0.85 | (56, 35) | 3 | 0.04 |

| OUTAGES FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|--------------------|--------------------|----|------|------|----------|--------|
| 27321 SRAF-115 115 | 27391 TECO-115 115 | 1 | 24 | 133 | 0.18 | |
| 27181 15SE-115 115 | 27341 SMIG-115 115 | 1 | 42 | 133 | 0.31 | |

| OVERLOAD FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- |
|--------------------|--------------------|----|------|------|------------------|
| 27211 BERL-115 115 | 27341 SMIG-115 115 | 1 | 65 | 148 | 1.31 1.11 1.11 |

* AREA 2 *

| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | 0.7 | 0.9 | 1.1 |
|---------|-----------|-------|-------|-------|-------|--------|-----|-------|-----|
| 24391 | TECO-46 4 | 1.100 | 0.890 | 1.011 | 0.874 | -0.137 | . | ----- | . |
| 27341 | SMIG-115 | 1.100 | 0.890 | 0.972 | 0.883 | -0.089 | . | ----- | . |
| 27391 | TECO-115 | 1.100 | 0.890 | 0.980 | 0.851 | -0.129 | . | ----- | . |
| 27401 | OZAT-115 | 1.100 | 0.890 | 0.969 | 0.855 | -0.114 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 428 : BRANCH 1075 ++BRANCH 1070

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING GEN | ITER | MM |
|------|----------|-----------|-----------|----------|-----------|------|------|
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.87 | (59, 36) | 3 | 0.04 |

| OUTAGES FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|--------------------|--------------------|----|------|------|----------|--------|
| 27341 SMIG-115 115 | 27401 OZAT-115 115 | 1 | 20 | 133 | 0.15 | |
| 27211 BERL-115 115 | 27341 SMIG-115 115 | 1 | 65 | 133 | 0.49 | |

* AREA 2 *

| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | 0.7 | 0.9 | 1.1 |
|---------|----------|------|------|------|------|------|-----|-------|-----|
| | | | | | | | . | ----- | . |

27341 SMIG-115 1.100 0.890 0.972 0.871 -0.101 . ----- .

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 629 : BRANCH 1084 ++BRANCH 1070

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 3-1.10 0- 0.0 0-0.00 4-0.77 (68, 37) 3 0.09

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27391 TECO-115 115 27401 OZAT-115 115 1 11 133 0.08
27211 BERL-115 115 27341 SMIG-115 115 1 65 133 0.49

OVERLOAD FROM BUS TO BUS ID BASE CONT ---P.U. FLOWS---
24341 SMIG-46 46.0 27341 SMIG-115 115 1 44 -55 1.10 1.10 1.10
24341 SMIG-46 46.0 27341 SMIG-115 115 2 44 -55 1.10 1.10 1.10
27181 15SE-115 115 27341 SMIG-115 115 1 42 142 1.26 1.07 1.07

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
24341 SMIG-46 4 1.100 0.890 1.010 0.811 -0.199 . ----- .
24401 OZAT-46 4 1.100 0.890 1.023 0.806 -0.217 . ----- .
27341 SMIG-115 1.100 0.890 0.972 0.795 -0.177 . ----- .
27401 OZAT-115 1.100 0.890 0.969 0.770 -0.199 . ----- .

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 633 : BRANCH 1084 ++BRANCH 1065

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 0-0.00 0- 0.0 0-0.00 1-0.89 (53, 35) 3 0.03

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27391 TECO-115 115 27401 OZAT-115 115 1 11 133 0.08
27181 15SE-115 115 27341 SMIG-115 115 1 42 133 0.31

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
27401 OZAT-115 1.100 0.890 0.969 0.886 -0.083 . ----- .

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 648 : BRANCH 1087 ++BRANCH 1077

----- POST-CONTINGENCY RESULTS -----
SOLN OVERLOAD DELT-FLOW HIGH-VOLT LOW-VOLT SWING GEN ITER MM
- 0-0.00 0- 0.0 0-0.00 1-0.89 (56, 35) 3 0.04

OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B
27421 NCUS-115 115 27461 STOM-115 115 1 9 266 0.03
27361 SANT-115 115 27371 NEJA-115 115 1 68 266 0.26

* AREA 2 * 0.7 0.9 1.1
VOLTAGE BUS NAME MAX. MIN. BASE CONT DEV. *-----*-----*-----*
27361 SANT-115 1.100 0.890 0.973 0.889 -0.084 . ----- .

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.89, BUSES/ISLD>= 1)

CONTINGENCY 696 : BRANCH 1090 ++BRANCH 1085

```

----- POST-CONTINGENCY RESULTS -----
SOLN   OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER   MM
      -      0-0.00    0- 0.0    0-0.00    1-0.89   ( 57, 35)  3   0.02

OUTAGES FROM BUS      TO BUS      ID  BASE CASE  RATING-B  P.U.-B
27431 SMAR-115 115 27461 STOM-115 115 1      78      266      0.29
27411 SONS-115 115 27441 ATEO-115 115 1      70      133      0.53

* AREA 2 *
VOLTAGE BUS NAME      MAX.      MIN.      BASE      CONT      DEV.      0.7      0.9      1.1
      27471 PEDR-115    1.100    0.890    0.964    0.886    -0.078    .      -----*-----*-----*

```

El resumen de los resultados se presenta en la siguiente tabla:

Cuadro 1 – Voltaje en p.u. de barras con violaciones de voltaje (0.89 p.u.).

| CONTINGENCIAS N-2 | Barras con Violaciones de Voltaje | | | | | | | |
|-----------------------|-----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--|
| | SMIG -115 | TECO -115 | OZAT -115 | NCUS -115 | STOM -115 | PEDR -115 | SANT -115 | |
| BERL-SMIG & CGRA-U1 | 0.888 | | | | | | | |
| BERL-SMIG & 15SE-U1 | 0.883 | | | | | | | |
| SMAR-STOM & ACAJ-ATEO | | | | 0.887 | 0.878 | 0.871 | | |
| SANT-NEJA & ACAJ-ATEO | | | | | | | 0.878 | |
| BERL-SMIG & 15SE-SMIG | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | |
| SRAF-TECO & BERL-SMIG | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | |
| TECO-OZAT & BERL-SMIG | 0.795* | | 0.770* | | | | | |
| SMIG-OZAT & BERL-SMIG | 0.871 | | | | | | | |
| SRAF-TECO & 15SE-SMIG | 0.883 | 0.851* | 0.855 | | | | | |
| NCUS-STOM & SANT-NEJA | | | | | | | 0.889 | |
| SMAR-STOM & SONS-ATEO | | | | | | 0.886 | | |
| TECO-OZAT & 15SE-SMIG | | | 0.886 | | | | | |
| SMAR-STOM & SANT-NEJA | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | |

Nota: (*) significa que también hay bajo voltaje en el secundario del transformador.

3.2.5. Caso E: Máxima transferencia El Salvador--> Honduras 100 MW

Archivo: MX_EH_100.raw (versión 26 convertida de MX_EH_100.sav)

Con el objeto de evitar el analizar los casos menos críticos, primeramente se hizo un análisis de la cantidad de casos de contingencias N-2 que se producen en función del límites inferior de voltaje para el cual se considera un abatimiento del voltaje extremo:

| Límite inferior de voltaje en nodos (p.u.) | Número de casos con violación del límite inferior de voltaje | Número de casos con colapso de voltaje | Número de casos de no convergencia |
|--|--|--|------------------------------------|
|--|--|--|------------------------------------|

| | | | |
|------|-----|---|---|
| 0.90 | 194 | 1 | 2 |
| 0.89 | 93 | 1 | 2 |
| 0.88 | 9 | 1 | 2 |
| 0.87 | 5 | 1 | 2 |
| 0.86 | 4 | 1 | 2 |

Del cuadro anterior, se concluye que dos casos de “No-convergencia” y que un caso de “colapso de voltaje”, que son una constante en todos los escenarios posibles; y que además, como punto de partida, se analizarán los 9 casos de bajo voltaje con respecto a la violación de límite inferior de 0.88 p.u. de voltaje, cuyos resultados se muestran a continuación:

*** CONTINGENCY RESULTS SUMMARY ***

```
TOTAL NO. OF CONTINGENCIES TESTED      =    727
I.   CONVERGED CONTINGENCIES           =    724
II.  VOLTAGE COLLAPSE CONTINGENCIES    =     1
III. NOT CONVERGED CONTINGENCIES       =     2
```

*** FAILURE SUMMARY ***

| FAILURE CRITERIA | NO. OF FAILURES | WORST INDEX | CASE VALUE |
|--|-----------------|-------------|------------|
| I. CONVERGED (724 CONTINGENCIES) : | | | |
| AT LEAST (1) BUSES PER ISLAND | 0 | 0 (0) | |
| OVERLOAD ABOVE (1.00) PU OF RATING (B) | 13 | 277 (1.56) | |
| CHANGE IN FLOW ABOVE (999.0%) | 0 | 0 (0.0) | |
| BUS VOLTAGE ABOVE (1.10) P.U. | 0 | 0 (0.00) | |
| BUS VOLTAGE BELOW (0.88) P.U. | 9 | 555 (0.76) | |
| SUBTOTAL | 19 | | |
| II. VOLTAGE COLLAPSE: | 1 | | |
| III. NOT-CONVERGED (MM > 0.10) | 2 | | |
| TOTAL FAILED CONTINGENCIES : | 22 | | |
| (OUT OF 727 CONTINGENCIES TESTED) | | | |

Los resultados indican lo siguiente:

- El TPLAN realizó 727 contingencias de líneas de transmisión y de generación.
- 9 casos de contingencias presentan violación del límite inferior de la banda de emergencia de voltaje (0.89 p.u.).
- Hay 13 casos de violación por sobrecarga de líneas de transmisión, los cuales no son objeto del presente estudio.
- Hay casos 1 caso de colapso de voltaje y 2 casos de no convergencia en la solución de flujo de potencia.

Un resumen detallado de los casos de bajo voltaje se muestra a continuación:

```
SUMMARY OF FAILED CONTINGENCIES
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD>= 1)
-----
CONTINGENCY 285 : BRANCH 1090 ++BRANCH 1055

----- POST-CONTINGENCY RESULTS -----
SOLN  OVERLOAD DELT-FLOW HIGH-VOLT  LOW-VOLT  SWING GEN ITER  MM
-      1-1.08    0- 0.0    0-0.00    2-0.85  ( -43, 39)  4    0.04
```

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|--------------------|-----|------|------|----------|--------|
| 27431 | SMAR-115 | 115 27461 STOM-115 | 115 | 1 | 59 | 266 | 0.22 |
| 27131 | ACAJ-115 | 115 27441 ATEO-115 | 115 | 1 | 85 | 266 | 0.32 |

| OVERLOAD FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- | | |
|-------------------|----------|--------------------|------|------|------------------|-----|----------------|
| 27411 | SONS-115 | 115 27441 ATEO-115 | 115 | 1 | 69 | 144 | 1.27 1.08 1.08 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|----------|-------|-------|-------|-------|--------|---------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 27461 | STOM-115 | 1.100 | 0.880 | 0.965 | 0.869 | -0.096 | . | ----- | . |
| 27471 | PEDR-115 | 1.100 | 0.880 | 0.951 | 0.853 | -0.098 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLVD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD=>= 1)

CONTINGENCY 288 : BRANCH 1073 ++BRANCH 1055

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.88 | (-43, | 39) | 3 | 0.06 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|--------------------|-----|------|------|----------|--------|
| 27321 | SRAF-115 | 115 27391 TECO-115 | 115 | 1 | 37 | 133 | 0.28 |
| 27131 | ACAJ-115 | 115 27441 ATEO-115 | 115 | 1 | 85 | 266 | 0.32 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|----------|-------|-------|-------|-------|--------|---------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 27391 | TECO-115 | 1.100 | 0.880 | 0.970 | 0.879 | -0.091 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLVD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD=>= 1)

CONTINGENCY 302 : BRANCH 1070 ++BRANCH 1065

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| NC- | 3-1.68 | 0- 0.0 | 0-0.00 | 6-0.19 | (-67, | 42) | 20 | 7.45 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|--------------------|-----|------|------|----------|--------|
| 27211 | BERL-115 | 115 27341 SMIG-115 | 115 | 1 | 61 | 133 | 0.46 |
| 27181 | 15SE-115 | 115 27341 SMIG-115 | 115 | 1 | 39 | 133 | 0.29 |

| OVERLOAD FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- | | |
|-------------------|----------|--------------------|------|------|------------------|------|----------------|
| 27321 | SRAF-115 | 115 27391 TECO-115 | 115 | 1 | 37 | 224 | 1.98 1.68 1.68 |
| 27341 | SMIG-115 | 115 27401 OZAT-115 | 115 | 1 | 8 | -166 | 1.47 1.25 1.25 |
| 27391 | TECO-115 | 115 27401 OZAT-115 | 115 | 1 | 17 | 203 | 1.80 1.53 1.53 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|----------|---------|-------|-------|-------|--------|---------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 24341 | SMIG-46 | 4 1.100 | 0.880 | 1.018 | 0.193 | -0.825 | ----- | ----- | . |
| 24391 | TECO-46 | 4 1.100 | 0.880 | 1.015 | 0.724 | -0.291 | ----- | ----- | . |
| 24401 | OZAT-46 | 4 1.100 | 0.880 | 1.027 | 0.483 | -0.544 | ----- | ----- | . |
| 27341 | SMIG-115 | 1.100 | 0.880 | 0.965 | 0.257 | -0.708 | ----- | ----- | . |
| 27391 | TECO-115 | 1.100 | 0.880 | 0.970 | 0.701 | -0.269 | ----- | ----- | . |
| 27401 | OZAT-115 | 1.100 | 0.880 | 0.960 | 0.472 | -0.488 | ----- | ----- | . |

| VAR | | | | | | | GENERATORS ON VAR LIMIT | | |
|-------|---------|---|-----|-----|-----|-----|-------------------------|--|---|
| 21101 | 5NOV-U1 | 1 | 7.0 | 0.0 | 3.7 | 7.0 | 3.3 | | + |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLVD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD=>= 1)

CONTINGENCY 303 : BRANCH 1073 ++BRANCH 1070

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|-------|-----|------|------|
| NC- | 1-1.95 | 0- 0.0 | 0-0.00 | 6-0.41 | (-1, | 37) | 20 | 5.27 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|-----------|----------|------|------|----------|----------|
| 27321 | SRAF-115 | 115 27391 | TECO-115 | 115 | 1 | 37 | 133 0.28 |
| 27211 | BERL-115 | 115 27341 | SMIG-115 | 115 | 1 | 61 | 133 0.46 |

| OVERLOAD | FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- |
|----------|----------|-----------|----------|------|------|-----------------------|
| 27181 | 15SE-115 | 115 27341 | SMIG-115 | 115 | 1 | 39 259 2.29 1.95 1.95 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|----------|---------|-------|-------|-------|--------|---------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 24341 | SMIG-46 | 4 1.100 | 0.880 | 1.018 | 0.523 | -0.495 | ----- | ----- | ----- |
| 24391 | TECO-46 | 4 1.100 | 0.880 | 1.015 | 0.414 | -0.601 | ----- | ----- | ----- |
| 24401 | OZAT-46 | 4 1.100 | 0.880 | 1.027 | 0.457 | -0.570 | ----- | ----- | ----- |
| 27341 | SMIG-115 | 1.100 | 0.880 | 0.965 | 0.543 | -0.422 | ----- | ----- | ----- |
| 27391 | TECO-115 | 1.100 | 0.880 | 0.970 | 0.418 | -0.552 | ----- | ----- | ----- |
| 27401 | OZAT-115 | 1.100 | 0.880 | 0.960 | 0.452 | -0.508 | ----- | ----- | ----- |

SUMMARY OF FAILED CONTINGENCIES
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD=>= 1)

CONTINGENCY 344 : BRANCH 1086 ++BRANCH 1073

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.88 | (-44, | 39) | 2 | 0.06 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|-----------|----------|------|------|----------|----------|
| 27421 | NCUS-115 | 115 27441 | ATEO-115 | 115 | 1 | 98 | 266 0.37 |
| 27321 | SRAF-115 | 115 27391 | TECO-115 | 115 | 1 | 37 | 133 0.28 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|----------|-------|-------|-------|-------|--------|---------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 27391 | TECO-115 | 1.100 | 0.880 | 0.970 | 0.877 | -0.093 | ----- | ----- | ----- |

SUMMARY OF FAILED CONTINGENCIES
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD=>= 1)

CONTINGENCY 345 : BRANCH 1073 ++BRANCH 1065

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| - | 1-1.22 | 0- 0.0 | 0-0.00 | 6-0.78 | (-44, | 39) | 3 | 0.09 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------|-----------|----------|------|------|----------|----------|
| 27321 | SRAF-115 | 115 27391 | TECO-115 | 115 | 1 | 37 | 133 0.28 |
| 27181 | 15SE-115 | 115 27341 | SMIG-115 | 115 | 1 | 39 | 133 0.29 |

| OVERLOAD | FROM BUS | TO BUS | ID | BASE | CONT | ---P.U. FLOWS--- |
|----------|----------|-----------|----------|------|------|-----------------------|
| 27211 | BERL-115 | 115 27341 | SMIG-115 | 115 | 1 | 61 162 1.43 1.22 1.22 |

| * AREA | 2 * | | | | | | 0.7 | 0.9 | 1.1 |
|---------|----------|---------|-------|-------|-------|--------|---------|---------|---------|
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----* | *-----* | *-----* |
| 24341 | SMIG-46 | 4 1.100 | 0.880 | 1.018 | 0.879 | -0.139 | ----- | ----- | ----- |
| 24391 | TECO-46 | 4 1.100 | 0.880 | 1.015 | 0.811 | -0.204 | ----- | ----- | ----- |
| 24401 | OZAT-46 | 4 1.100 | 0.880 | 1.027 | 0.848 | -0.179 | ----- | ----- | ----- |
| 27341 | SMIG-115 | 1.100 | 0.880 | 0.965 | 0.842 | -0.123 | ----- | ----- | ----- |
| 27391 | TECO-115 | 1.100 | 0.880 | 0.970 | 0.781 | -0.189 | ----- | ----- | ----- |
| 27401 | OZAT-115 | 1.100 | 0.880 | 0.960 | 0.798 | -0.162 | ----- | ----- | ----- |

SUMMARY OF FAILED CONTINGENCIES
(OVLDT> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD=>= 1)

CONTINGENCY 347 : BRANCH 1073 ++BRANCH 1050

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.88 | (-47, | 40) | 2 | 0.05 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------------|--------------------|-----|------|------|----------|--------|
| | 27321 SRAF-115 | 115 27391 TECO-115 | 115 | 1 | 37 | 133 | 0.28 |
| | 27101 5NOV-115 | 115 27321 SRAF-115 | 115 | 1 | 58 | 266 | 0.22 |

* AREA 2 *

| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | 0.7 | 0.9 | 1.1 |
|---------|----------|-------|-------|-------|-------|--------|-----|-------|-----|
| 27391 | TECO-115 | 1.100 | 0.880 | 0.970 | 0.879 | -0.091 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD>= 1)

CONTINGENCY 348 : BRANCH 1073 ++BRANCH 1071

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.88 | (-47, | 40) | 2 | 0.06 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------------|--------------------|-----|------|------|----------|--------|
| | 27321 SRAF-115 | 115 27391 TECO-115 | 115 | 1 | 37 | 133 | 0.28 |
| | 27301 SOYA-115 | 115 27371 NEJA-115 | 115 | 1 | 87 | 266 | 0.33 |

* AREA 2 *

| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | 0.7 | 0.9 | 1.1 |
|---------|----------|-------|-------|-------|-------|--------|-----|-------|-----|
| 27391 | TECO-115 | 1.100 | 0.880 | 0.970 | 0.879 | -0.091 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD>= 1)

CONTINGENCY 402 : BRANCH 1090 ++BRANCH 1077

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| VC- | 0-0.00 | 0- 0.0 | 0-0.00 | 12-0.70 | (-36, | 38) | 14 | 1.55 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------------|--------------------|-----|------|------|----------|--------|
| | 27431 SMAR-115 | 115 27461 STOM-115 | 115 | 1 | 59 | 266 | 0.22 |
| | 27361 SANT-115 | 115 27371 NEJA-115 | 115 | 1 | 44 | 266 | 0.17 |

* AREA 2 *

| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | 0.7 | 0.9 | 1.1 |
|---------|-----------|-------|-------|-------|-------|--------|-----|-------|-----|
| 21441 | ATEO-GM 1 | 1.100 | 0.880 | 1.018 | 0.849 | -0.169 | . | ----- | . |
| 22361 | SANT-23 2 | 1.100 | 0.880 | 1.023 | 0.800 | -0.223 | . | ----- | . |
| 22421 | NCUS-23 2 | 1.100 | 0.880 | 1.024 | 0.773 | -0.251 | . | ----- | . |
| 23441 | ATEO-34 3 | 1.100 | 0.880 | 1.025 | 0.839 | -0.186 | . | ----- | . |
| 24441 | ATEO-46 4 | 1.100 | 0.880 | 1.022 | 0.842 | -0.180 | . | ----- | . |
| 24461 | STOM-46 4 | 1.100 | 0.880 | 1.027 | 0.763 | -0.264 | . | ----- | . |
| 24471 | PEDR-46 4 | 1.100 | 0.880 | 1.024 | 0.747 | -0.277 | . | ----- | . |
| 27361 | SANT-115 | 1.100 | 0.880 | 0.976 | 0.773 | -0.203 | . | ----- | . |
| 27421 | NCUS-115 | 1.100 | 0.880 | 0.966 | 0.744 | -0.222 | . | ----- | . |
| 27441 | ATEO-115 | 1.100 | 0.880 | 0.984 | 0.808 | -0.176 | . | ----- | . |
| 27461 | STOM-115 | 1.100 | 0.880 | 0.965 | 0.721 | -0.244 | . | ----- | . |
| 27471 | PEDR-115 | 1.100 | 0.880 | 0.951 | 0.701 | -0.250 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVLD> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD>= 1)

CONTINGENCY 541 : BRANCH 1075 ++BRANCH 1070

----- POST-CONTINGENCY RESULTS -----

| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM |
|------|----------|-----------|-----------|----------|--------|-----|------|------|
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.86 | (-44, | 39) | 3 | 0.04 |

| OUTAGES | FROM BUS | TO BUS | ID | BASE | CASE | RATING-B | P.U.-B |
|---------|----------------|--------------------|-----|------|------|----------|--------|
| | 27341 SMIG-115 | 115 27401 OZAT-115 | 115 | 1 | 8 | 133 | 0.06 |
| | 27211 BERL-115 | 115 27341 SMIG-115 | 115 | 1 | 61 | 133 | 0.46 |

* AREA 2 *

| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | 0.7 | 0.9 | 1.1 |
|---------|----------|-------|-------|-------|-------|--------|-----|-------|-----|
| 27341 | SMIG-115 | 1.100 | 0.880 | 0.965 | 0.858 | -0.107 | . | ----- | . |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVL> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD>= 1)

CONTINGENCY 555 : BRANCH 1084 ++BRANCH 1070

| ----- POST-CONTINGENCY RESULTS ----- | | | | | | | | | |
|--|----------|-----------|-----------|----------|--------|--------|---------------------|-----------|----------------|
| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM | |
| - | 1-1.11 | 0- 0.0 | 0-0.00 | 4-0.76 | (-35, | 39) | 3 | 0.07 | |
| OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B | | | | | | | | | |
| 27391 | TECO-115 | 115 | 27401 | OZAT-115 | 115 | 1 | 17 | 133 | 0.13 |
| 27211 | BERL-115 | 115 | 27341 | SMIG-115 | 115 | 1 | 61 | 133 | 0.46 |
| OVERLOAD FROM BUS TO BUS ID BASE CONT ---P.U. FLOWS--- | | | | | | | | | |
| 27181 | 15SE-115 | 115 | 27341 | SMIG-115 | 115 | 1 | 39 | 147 | 1.30 1.11 1.11 |
| * AREA 2 * 0.7 0.9 1.1 | | | | | | | | | |
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----*-----*-----* | | |
| 24341 | SMIG-46 | 4 | 1.100 | 0.880 | 1.018 | 0.815 | -0.203 | . ----- . | |
| 24401 | OZAT-46 | 4 | 1.100 | 0.880 | 1.027 | 0.808 | -0.219 | . ----- . | |
| 27341 | SMIG-115 | 1.100 | 0.880 | 0.965 | 0.787 | -0.178 | . ----- . | | |
| 27401 | OZAT-115 | 1.100 | 0.880 | 0.960 | 0.761 | -0.199 | . ----- . | | |

S U M M A R Y O F F A I L E D C O N T I N G E N C I E S
(OVL> 1.00 RATEB, V.COLLAPSE<0.50, VOLT>1.10, VOLT<0.88, BUSES/ISLD>= 1)

CONTINGENCY 557 : BRANCH 1084 ++BRANCH 1065

| ----- POST-CONTINGENCY RESULTS ----- | | | | | | | | | |
|--|----------|-----------|-----------|----------|--------|--------|---------------------|------|------|
| SOLN | OVERLOAD | DELT-FLOW | HIGH-VOLT | LOW-VOLT | SWING | GEN | ITER | MM | |
| - | 0-0.00 | 0- 0.0 | 0-0.00 | 1-0.87 | (-49, | 40) | 3 | 0.04 | |
| OUTAGES FROM BUS TO BUS ID BASE CASE RATING-B P.U.-B | | | | | | | | | |
| 27391 | TECO-115 | 115 | 27401 | OZAT-115 | 115 | 1 | 17 | 133 | 0.13 |
| 27181 | 15SE-115 | 115 | 27341 | SMIG-115 | 115 | 1 | 39 | 133 | 0.29 |
| * AREA 2 * 0.7 0.9 1.1 | | | | | | | | | |
| VOLTAGE | BUS NAME | MAX. | MIN. | BASE | CONT | DEV. | *-----*-----*-----* | | |
| 27401 | OZAT-115 | 1.100 | 0.880 | 0.960 | 0.868 | -0.092 | . ----- . | | |

El resumen de los resultados se presenta en la siguiente tabla:

Cuadro 1 – Voltaje en p.u. de barras con violaciones de voltaje (0.88 p.u.).

| CONTINGENCIAS N-2 | Barras con Violaciones de Voltaje | | | | | | |
|-----------------------|-----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| | SMIG -115 | TECO -115 | OZAT -115 | NCUS -115 | STOM -115 | PEDR -115 | SANT -115 |
| SMAR-STOM & ACAJ-ATEO | | | | | 0.869 | 0.853 | |
| SRAF-TECO & ACAJ-ATEO | | 0.879 | | | | | |
| BERL-SMIG & 15SE-SMIG | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. |
| SRAF-TECO & BERL-SMIG | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. | N.C. |
| TECO-OZAT & BERL-SMIG | 0.787* | | 0.761* | | | | |
| NCUS-ATEO & SRAF-TECO | | 0.877 | | | | | |
| SMIG-OZAT & BERL-SMIG | 0.858 | | | | | | |
| SRAF-TECO & 15SE-SMIG | 0.842* | 0.781* | 0.798* | | | | |
| SRAF-TECO & 5NOV-SRAF | | 0.879 | | | | | |
| SRAF-TECO & SOYA-NEJA | | 0.879 | | | | | |
| TECO-OZAT & 15SE-SMIG | | | 0.868 | | | | |
| SMAR-STOM & SANT-NEJA | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. | V.C. |

Nota: (*) significa que también hay bajo voltaje en el secundario del transformador.

3.3. Resultados y conclusiones:

a. Un cuadro resumen de resultados para las contingencias N-1 es el siguiente:

| CONTINGENCIAS N-1 | NODO 115 KV | caso base | G->E 56 | E->G 90 | H->E 104 | E->H 100 |
|-------------------|-------------|-----------|--------------|---------|----------|----------|
| BERL-SMIG | SMIG | 0.886 | 0.884 | | | 0.894 |
| SRAF-TECO | TECO | 0.874 | 0.87 | | | 0.881 |
| | OZAT | 0.889 | | | | 0.896 |
| SMAR-STOM | STOM | | 0.897 | | | |
| | PEDR | 0.889 | 0.881 | | | 0.89 |

b. Un cuadro resumen de resultados para las contingencias N-2 es el siguiente:

| CONTINGENCIAS N-2 | NODO 115 KV | caso base | G->E 56 | E->G 90 | H->E 104 | E->H 100 |
|-----------------------|-------------|-------------|---------------|---------------|--------------|-------------|
| BERL-SMIG & 15SE-SMIG | | V.C. | V.C. | V.C. | N.C. | N.C. |
| BERL-SMIG & 15SE-U1 | SMIG | | | | 0.883 | |
| BERL-SMIG & CGRA-U1 | SMIG | | | | 0.888 | |
| NCUS-ATEO & SRAF-TECO | TECO | 0.868 | 0.865 | | | 0.877 |
| | OZAT | 0.886 | | | | |
| NCUS-STOM & SANT-NEJA | SANT | | | | 0.889 | |
| NEJA-SMAR & SRAF-TECO | TECO | | 0.869 | | | |
| SANT-NEJA & ACAJ-ATEO | SANT | | | | 0.878 | |
| SMAR-STOM & ACAJ-ATEO | NCUS | 0.886 | | 0.889 | 0.887 | |
| | STOM | 0.866 | 0.863 | 0.876 | 0.878 | 0.869 |
| | PEDR | 0.85 | 0.846 | 0.86 | 0.871 | 0.853 |
| SMAR-STOM & SANT-NEJA | | N.C. | V.C. | V.C. | N.C. | V.C. |
| SMAR-STOM & SONS-ATEO | PEDR | 0.865 | | | 0.886 | |
| SMIG-OZAT & BERL-SMIG | SMIG | 0.847 | 0.843 | 0.886 | 0.871 | 0.858 |
| SRAF-TECO & 15SE-SMIG | SMIG | 0.827* | 0.818* | | 0.883 | 0.842* |
| | TECO | 0.763* | 0.753* | | 0.851* | 0.781* |
| | OZAT | 0.781* | 0.771* | | 0.855 | 0.798* |
| SRAF-TECO & 15SE-U1 | TECO | 0.856 | 0.853 | | | |
| | OZAT | 0.874 | 0.869 | | | |
| SRAF-TECO & 5NOV-SRAF | TECO | | 0.867 | | | 0.879 |
| SRAF-TECO & ACAJ-ATEO | TECO | | 0.867 | | | 0.879 |
| SRAF-TECO & AHUA-SANA | TECO | | 0.869 | | | |
| SRAF-TECO & BERL-SMIG | SMIG | N.C. | N.C. | 0.725* | V.C. | N.C. |
| | TECO | | | 0.666* | | |
| | OZAT | | | 0.678* | | |
| SRAF-TECO & BERL-U1 | TECO | 0.866 | | | | |
| | OZAT | 0.883 | | | | |
| SRAF-TECO & BERL-U3 | TECO | 0.865 | | | | |
| | OZAT | 0.882 | | | | |
| SRAF-TECO & SOYA-NEJA | TECO | | 0.868 | | | 0.879 |
| TECO-OZAT & 15SE-SMIG | OZAT | 0.865 | 0.859 | | 0.886 | 0.868 |
| TECO-OZAT & BERL-SMIG | SMIG | 0.763* | 0.756* | 0.819* | 0.795* | 0.787* |
| | OZAT | 0.736* | 0.729* | 0.795* | 0.770* | 0.761* |

- c. Los nodos afectados (de mayor a menor) por bajo voltaje son: TECO, OZAT, SMIG, PEDR, STOM, NCUS, SANT.
- d. La contingencia que mas problemas provoca son las que tiene asociada el disparo de la línea SRAF-TECO.
- e. El escenario que presenta los peores perfiles de voltaje corresponde a la importación de 56 MW desde Guatemala.
- f. Se comprueba que una vez determinado cuál escenario de transferencia provoca los peores resultados para contingencias N-1, el escenario de transferencia que provoca los peores resultados para contingencias N-2 es el mismo.

4. ANÁLISIS DE ESTABILIDAD DE VOLTAJE

Del análisis precedente se vió que el pero escenario corresponde a la importación de Guatemala hacia El Salvador de 56 MW, el cual será el caso base en el presente análisis. Se efectuará el análisis modelando la carga como el 50% de potencia activa a corriente constante y el 50% de potencia reactiva a impedancia constante, lo cual supone que una parte de la carga es dependiente del voltaje y su efecto sobre el margen de potencia reactiva antes de llegar al punto de colapso de voltaje. Este modelo es mejor que considerar toda la carga a potencia constante, sin embargo, tampoco es tan optimista que si se modelara toda la carga a impedancia constante.

La metodología para el presente análisis, consiste en analizar las curvas V-Q de los nodos más afectados por abatimiento del voltaje cuando ocurre una contingencia N-1.

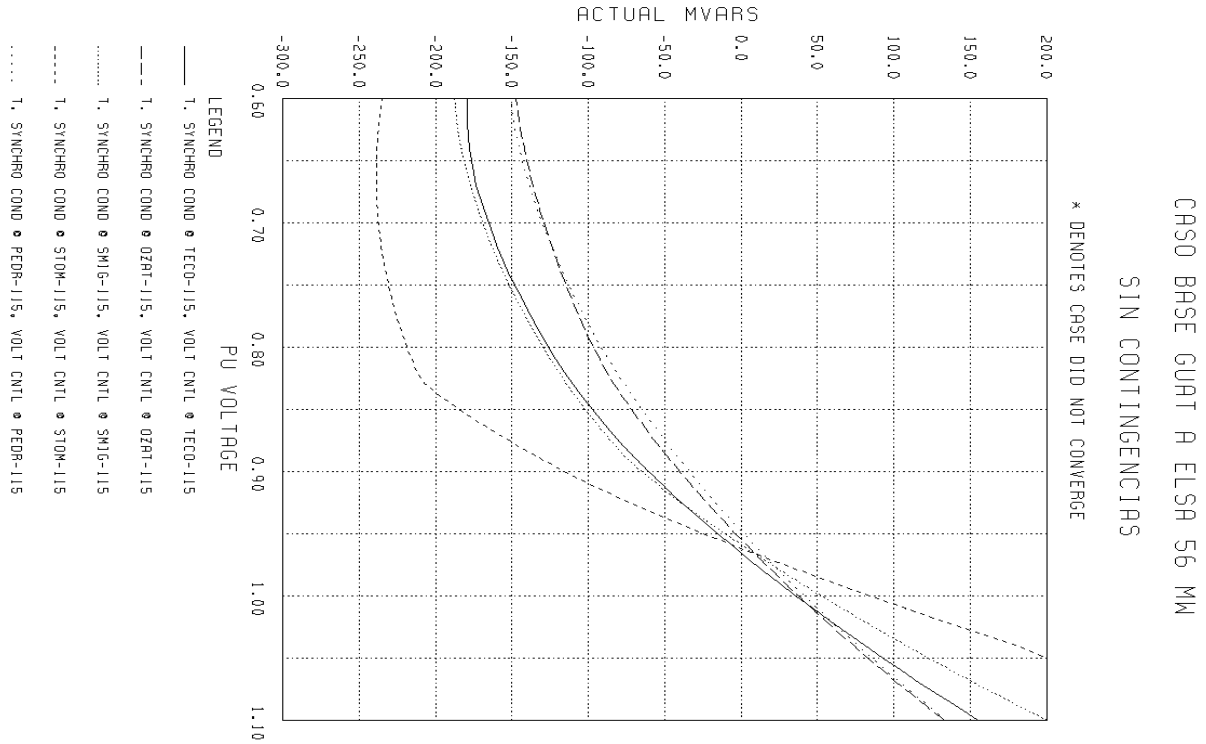
4.1. Reserva de reactivos para contingencias N-1

De los análisis precedentes, los nodos que aparecieron con problemas de violación del límite inferior de la banda de voltaje de operación de emergencia son los siguientes:

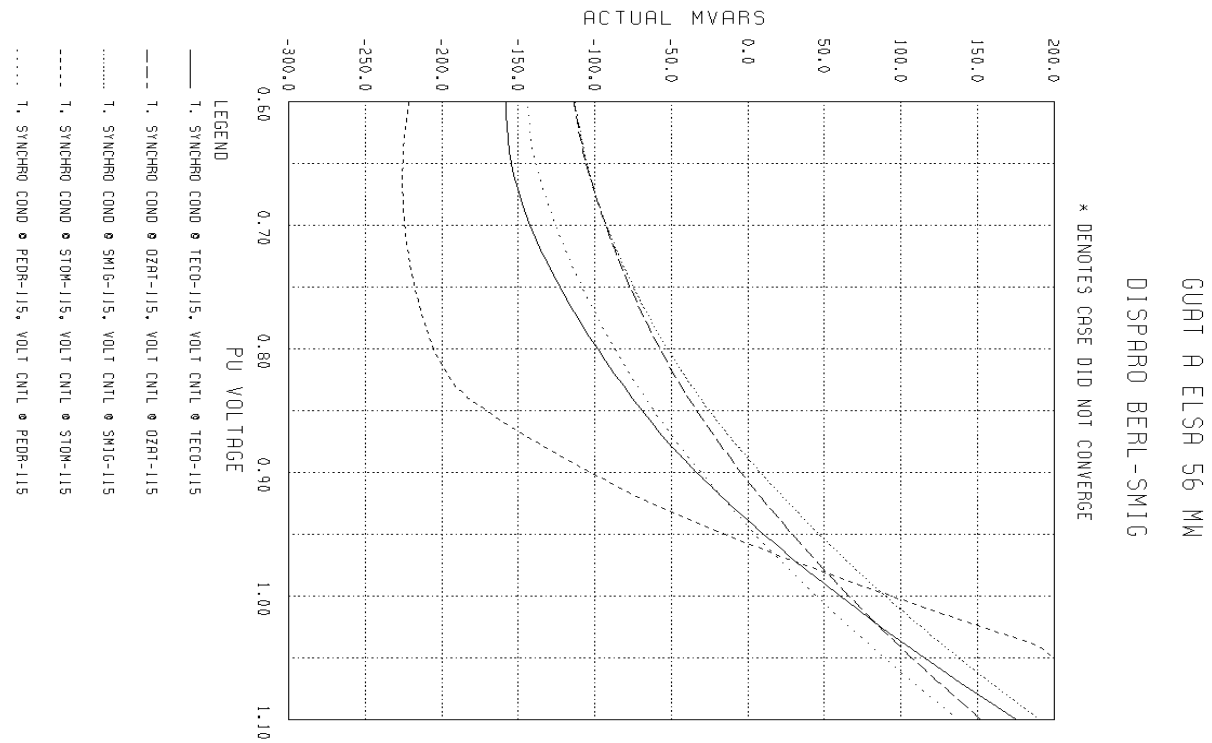
| Nodo | Causa |
|-------------------------------|----------------------------|
| San Miguel 115 kV | Disparo de línea BERL-SMIG |
| Tecoluca y Ozatlán 115 kV | Disparo de línea SRAF-TECO |
| Santo Tomás y Pedregal 115 kV | Disparo de línea SMAR-STOM |

A continuación se muestran las curvas V-Q para el caso base en condiciones normales de operación de estos nodos, y posteriormente, las curvas V-Q de los nodos reportados con violaciones de la banda de voltaje de emergencia:

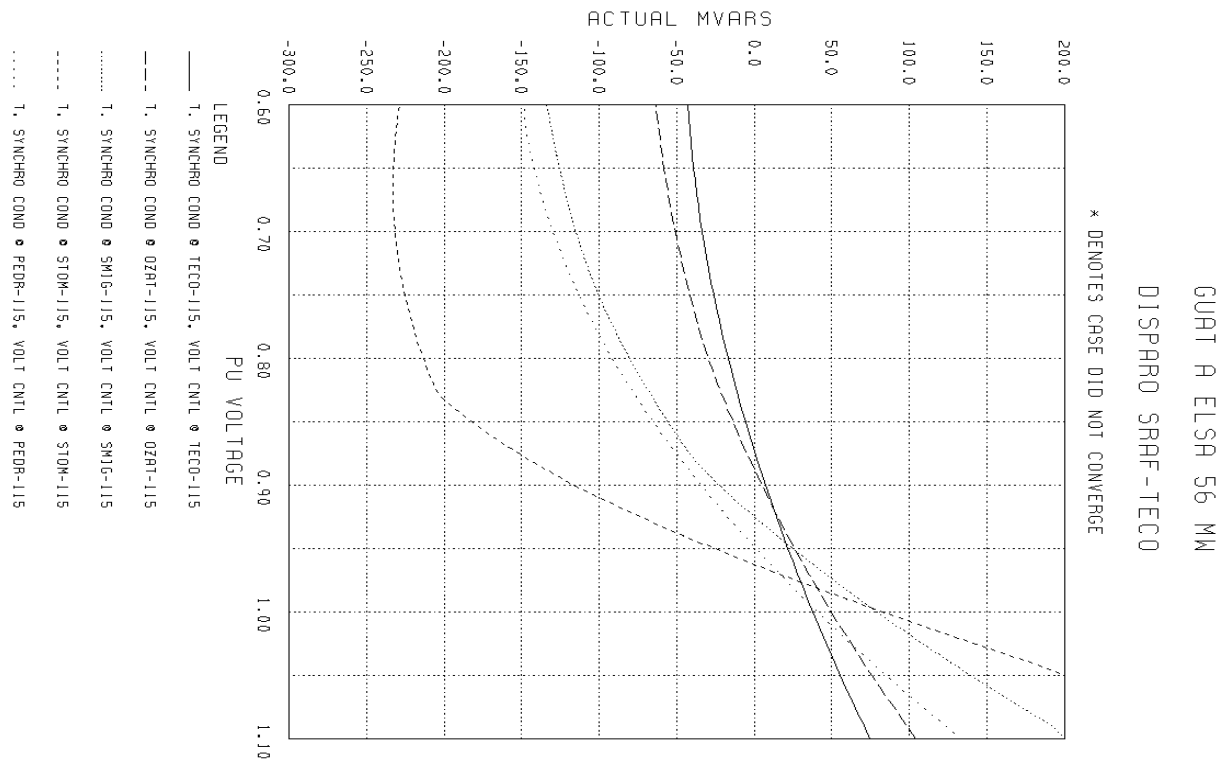
4.1.1. Caso base sin contingencias



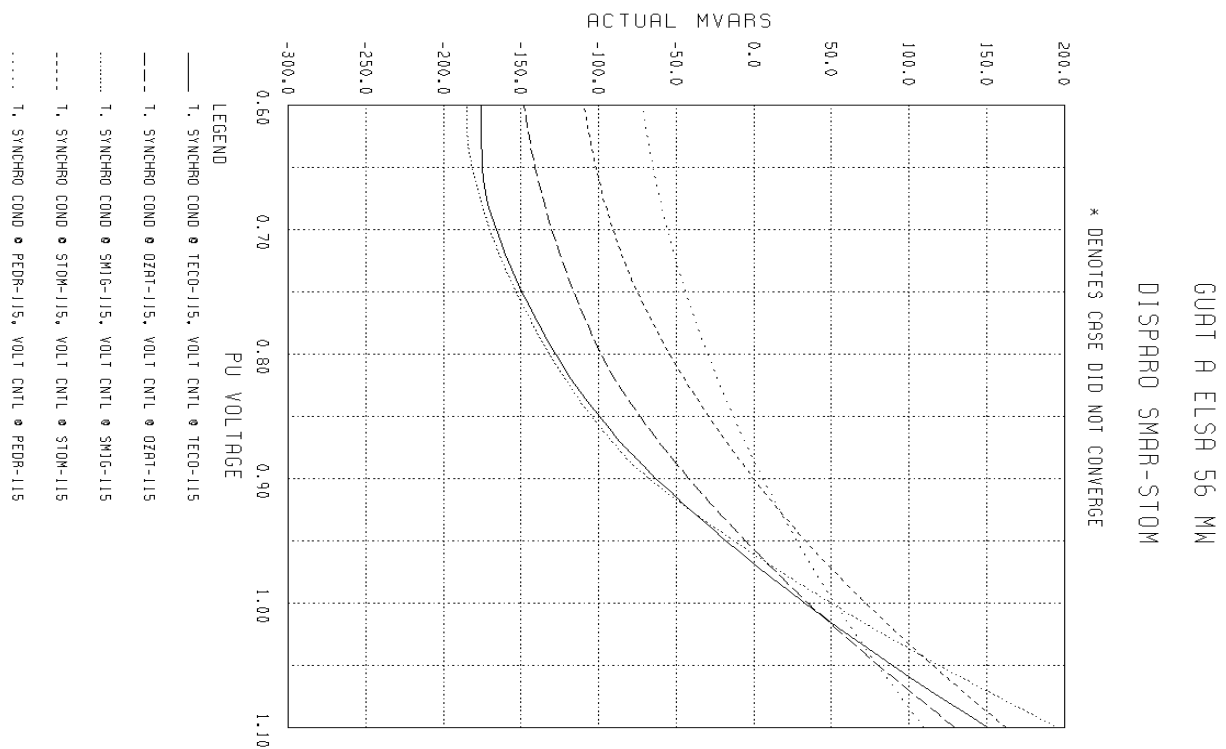
4.1.2. Caso base con disparo de línea Berlín – San Miguel



4.1.3. Caso base con disparo de línea San Rafael Cedros - Tecoluca



4.1.4. Caso base con disparo de línea San Martín – Santo Tomás



La siguiente tabla muestra los nodos más débiles y el margen de potencia reactiva por contingencia y por bus analizado:

| CASO: MX_GE56.CNV | BUSES | | | | |
|----------------------|----------|----------|----------|----------|----------|
| | TECO-115 | OZAT-115 | SMIG-115 | STOM-115 | PEDR-115 |
| BASE | 181 | 152 | 188 | 225 | 153 |
| BERL-SMIG | 162 | 121 | 122 | 213 | 148 |
| SRAF-TECO | 48 | 69 | 141 | 220 | 151 |
| SMAR-STOM | 180 | 152 | 188 | 113 | 80 |

4.2. Reserva de reactivos para contingencias N-2

| CASO: GUAT => ELSA 56 MW | BUSES | | | | | TOTAL |
|-----------------------------|----------|----------|----------|----------|----------|-------|
| | TECO-115 | OZAT-115 | SMIG-115 | STOM-115 | PEDR-115 | |
| BERL-SMIG & 15SE-SMIG | 102 | 24 | -2 | 174 | 119 | 417 |
| BERL-SMIG & 15SE-U1 | 148 | 119 | 121 | 188 | 133 | 709 |
| BERL-SMIG & CGRA-U1 | 143 | 118 | 122 | 181 | 126 | 690 |
| NCUS-ATEO & SRAF-TECO | 46 | 67 | 133 | 185 | 124 | 555 |
| NCUS-STOM & SANT-NEJA | 175 | 149 | 182 | 212 | 138 | 856 |
| NEJA-SMAR & SRAF-TECO | 47 | 68 | 137 | 217 | 147 | 616 |
| SANT-NEJA & ACAJ-ATEO | 167 | 144 | 175 | 195 | 138 | 819 |
| SMAR-STOM & ACAJ-ATEO | 167 | 144 | 175 | 104 | 72 | 662 |
| SMAR-STOM & SANT-NEJA | 164 | 146 | 175 | 34 | 26 | 545 |
| SMAR-STOM & SONS-ATEO | 170 | 147 | 179 | 104 | 72 | 672 |
| SMIG-OZAT & BERL-SMIG | 145 | 84 | 81 | 213 | 148 | 671 |
| SRAF-TECO & 15SE-SMIG | 28 | 37 | 62 | 210 | 147 | 484 |
| SRAF-TECO & 15SE-U1 | 43 | 63 | 126 | 184 | 133 | 549 |
| SRAF-TECO & 5NOV-SRAF | 47 | 68 | 138 | 214 | 149 | 616 |
| SRAF-TECO & ACAJ-ATEO | 47 | 68 | 135 | 201 | 139 | 590 |
| SRAF-TECO & AHUA-SANA | 47 | 68 | 136 | 203 | 139 | 593 |
| SRAF-TECO & BERL-SMIG | 17 | 24 | 48 | 194 | 141 | 424 |
| SRAF-TECO & BERL-U3 | 47 | 65 | 132 | 198 | 140 | 582 |
| SRAF-TECO & SOYA-NEJA | 47 | 68 | 137 | 211 | 145 | 608 |
| TECO-OZAT & 15SE-SMIG | 153 | 48 | 77 | 217 | 150 | 645 |
| TECO-OZAT & BERL-SMIG | 150 | 38 | 65 | 209 | 149 | 611 |

Del cuadro precedente, se presenta el mismo listado de contingencias ordenados por el total que resulta de sumar el margen de reactivos de los nodos mostrados; esto dará una indicación de cuáles son las peores contingencias.

| No. | CONTINGENCIA | TOTAL MVARs | No. | CONTINGENCIA | TOTAL MVARs |
|-----|-----------------------|-------------|-----|-----------------------|-------------|
| 1 | BERL-SMIG & 15SE-SMIG | 417 | 11 | TECO-OZAT & BERL-SMIG | 611 |
| 2 | SRAF-TECO & BERL-SMIG | 424 | 12 | NEJA-SMAR & SRAF-TECO | 616 |
| 3 | SRAF-TECO & 15SE-SMIG | 484 | 13 | SRAF-TECO & 5NOV-SRAF | 616 |
| 4 | SMAR-STOM & SANT-NEJA | 545 | 14 | TECO-OZAT & 15SE-SMIG | 645 |
| 5 | SRAF-TECO & 15SE-U1 | 549 | 15 | SMAR-STOM & ACAJ-ATEO | 662 |

| | | | | | |
|----|-----------------------|-----|----|-----------------------|-----|
| 6 | NCUS-ATEO & SRAF-TECO | 555 | 16 | SMIG-OZAT & BERL-SMIG | 671 |
| 7 | SRAF-TECO & BERL-U3 | 582 | 17 | SMAR-STOM & SONS-ATEO | 672 |
| 8 | SRAF-TECO & ACAJ-ATEO | 590 | 18 | BERL-SMIG & CGRA-U1 | 690 |
| 9 | SRAF-TECO & AHUA-SANA | 593 | 19 | BERL-SMIG & 15SE-U1 | 709 |
| 10 | SRAF-TECO & SOYA-NEJA | 608 | 20 | SANT-NEJA & ACAJ-ATEO | 819 |
| | | | 21 | NCUS-STOM & SANT-NEJA | 856 |

Análisis:

- Los nodos más débiles son Tecoluca y Ozatlán, seguido muy de cerca por San Miguel y El Pedregal; y el nodo crítico en este escenario de demanda es Tecoluca ante disparo de SRAF-TECO.
- La contingencia que presenta menos reserva de reactivos para el control del voltaje corresponde al disparo de la línea San Rafael Cedros- Tecoluca, dejando a Tecoluca con un margen de reserva de 48 Mvars, seguido por Ozatlán con un margen de 69 Mvars aproximadamente.
- La peor contingencia que puede ocurrir después de ocurrir la peor contingencia listadas en la Tabla son las siguientes:

| CASO | PEORES CONTINGENCIAS N-1 | SIGUIENTE PEOR CONTINGENCIA N-2 CON COLAPSO. | ID | SIGUIENTE PEOR CONTINGENCIA N-2 SIN C.V. | |
|------|--------------------------|--|----|--|----|
| 1 | BERL-SMIG | 15SE-SMIG | 1 | SMIG-OZAT | 16 |
| 2 | BERL-SMIG | SRAF-TECO | 2 | SMIG-OZAT | 16 |
| 3 | BERL-SMIG | TECO-OZAT | 11 | SMIG-OZAT | 16 |
| 4 | SMAR-STOM | SANT-NEJA | 4 | ACAJ-ATEO | 15 |
| 5 | SRAF-TECO | BERL-SMIG | 2 | 15SE-U1 | 5 |
| 6 | SRAF-TECO | 15SE-SMIG | 3 | NCUS-ATEO | 6 |

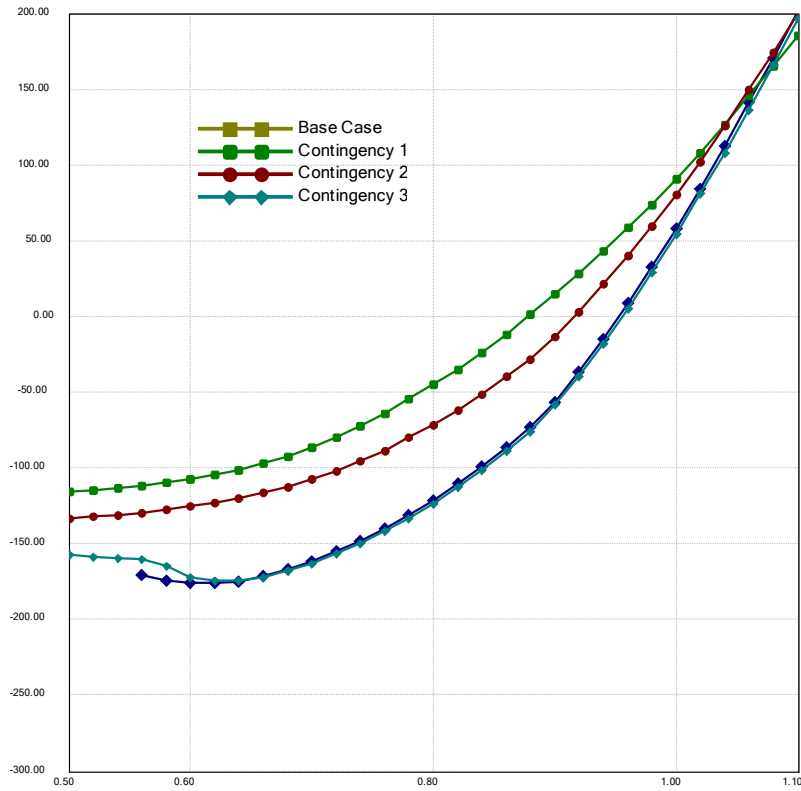
4.3. Cálculo del margen de reserva reactiva

A continuación se muestran las gráficas QV del caso base (MX_GE56.cnv) con la carga aumentada al 105% para las siguientes contingencias críticas:

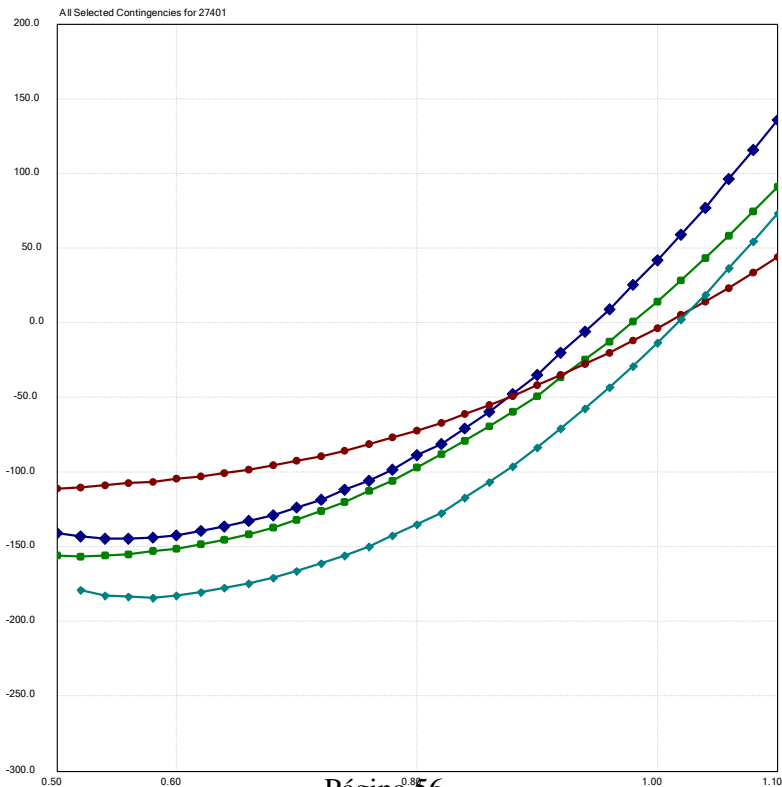
- Contingencia 1: BERL-SMIG
- Contingencia 2: SRAF-TECO
- Contingencia 3: SMAR-STOM

Las gráficas QV corresponde a los nodos críticos.

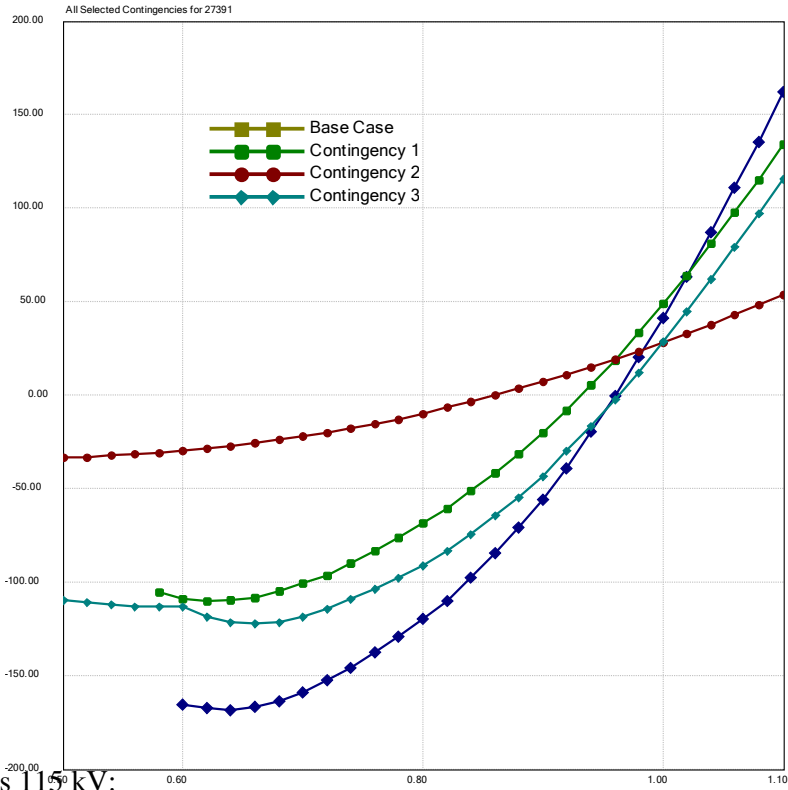
Nodo San Miguel 115 kV:



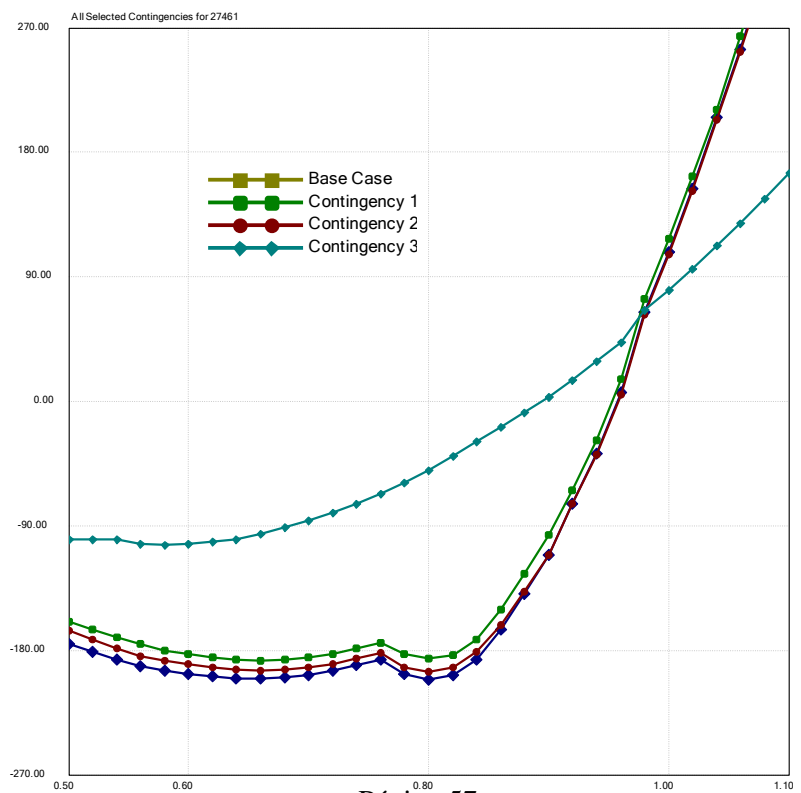
Nodo Ozatlan 115 kV:



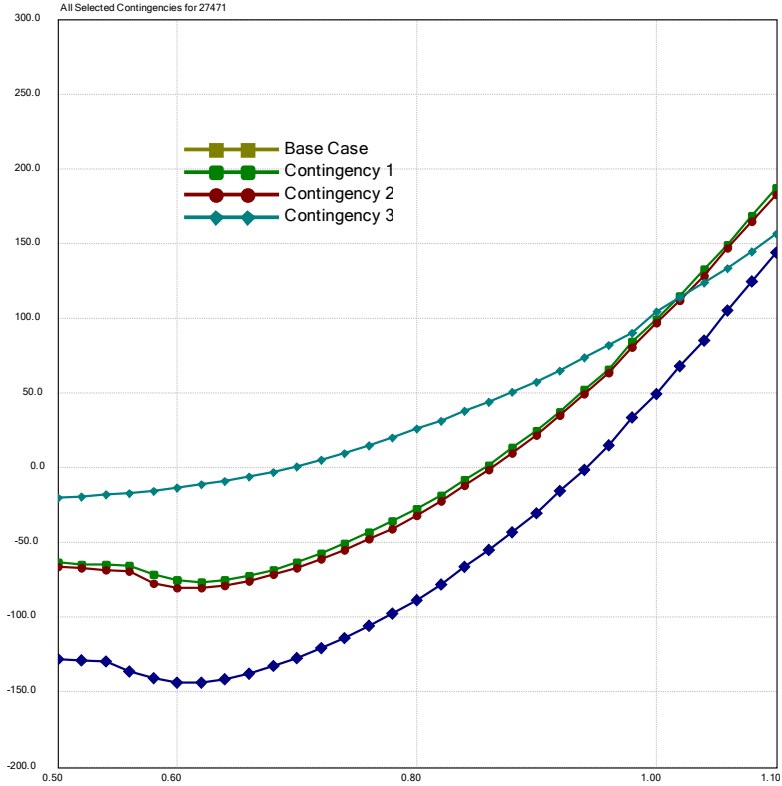
Nodo Tecoluca 115 kV:



Nodo Santo Tomás 115 kV:



Nodo El Pedregal 115 kV:



La siguiente tabla muestra los nodos más débiles y el margen de potencia reactiva por contingencia y por bus analizado:

| CASO MXA_GE56.CNV | BUSES | | | | |
|----------------------|----------|----------|----------|----------|----------|
| | TECO-115 | OZAT-115 | SMIG-115 | STOM-115 | PEDR-115 |
| BERL-SMIG | 149 | 115 | 115 | 188 | 137 |
| SRAF-TECO | 45 | 66 | 133 | 196 | 141 |
| SMAR-STOM | 165 | 145 | 177 | 104 | 76 |

| CASO | BUS VOLTAJE | MARGEN DE POTENCIA REACTIVA (MVAR) | | | MARGEN REQUERIDO (MVAR) | CUMPLIMIENTO DE CRITERIO? |
|-----------|----------------|---------------------------------------|-------------------|------------------|-------------------------------|------------------------------|
| | | N-0 CASO BASE | N-1 CARGA 100% | N-1 CARGA +5% | | |
| BERL-SMIG | SMIG-115 KV | 188 | 122 | 115 | 7 | Si |
| | OZAT-115 KV | 152 | 121 | 115 | 6 | Si |
| SRAF-TECO | TECO-115 KV | 181 | 48 | 45 | 3 | Si |

| | | | | | | |
|-----------|-------------|-----|-----|-----|---|----|
| | OZAT-115KV | 152 | 69 | 66 | 3 | Si |
| SMAR-STOM | STOM-115 KV | 225 | 113 | 104 | 9 | Si |
| | PEDR-115 KV | 153 | 80 | 76 | 4 | Si |

4.4. Determinación de las curvas P-V de las contingencias críticas

Para el presente análisis, se ha modelado la carga a potencia constante. La razón a la cual crece la generación corresponde a un paso de MW fijo ingresado manualmente tal que se aplica un escalamiento global de toda la generación en el área de El Salvador; del mismo modo, con el mismo paso, se aplica un escalamiento a toda la carga del área del El Salvador, manteniendo la misma razón P/Q de cada carga, dicha labor fue realizada con una programa en IPLAN “pv load curve.ipf”.

Para obtener las curvas PV, se realizó una disminución de la generación y carga con el método explicado arriba, en un 10% (MXr_GE56.SAV):

| X-- AREA --X | FROM GENERATION | TO LOAD | TO BUS SHUNT | TO LINE SHUNT | FROM CHARGING | TO NET INT | LOSSES | DESIRED NET INT |
|--------------|-----------------|---------|--------------|---------------|---------------|------------|--------|-----------------|
| 2 | 753.9 | 786.6 | 0.0 | 0.0 | 0.0 | -55.1 | 18.8 | 0.0 |
| SALVADOR | 281.1 | 203.5 | -56.1 | 0.0 | 87.1 | 4.3 | 193.9 | |
| TOTALS | 753.9 | 786.6 | 0.0 | 0.0 | 0.0 | -55.1 | 18.8 | 0.0 |
| | 281.1 | 203.5 | -56.1 | 0.0 | 87.1 | 4.3 | 193.9 | |

Durante las simulaciones de flujo de potencia de los casos base se asumió un modelo de carga MVA constante; el nodo oscilante se ubico fuera del área de El Salvador (se ubicó Chixoy) y se resolvieron los casos usando un método estándar FDNS. Las acciones automáticas de otros elementos del sistema para controlar el voltaje en el margen de tiempo de cero a tres minutos después del disturbio están también modelados: banco de capacitores, cambiadores automáticos de “taps” bajo carga de los transformadores reductores. Se aplicó las restricciones de límites de generación. Se aplicó las restricciones de límites de generación de reactivos. No hay controles suplementarios que operen en el marco de tiempo de tres minutos.

Para las simulaciones de flujo de potencia de los casos con contingencias se continuó usando el modelo de carga MVA constante para ser conservadores con los resultados; el nodo oscilante continúa en Chixoy (fuera del área) y se resolvieron los casos con FDNS, excepto los casos base de disparo de unidades, los cuales se resolvieron inicialmente con INLF, flujos de potencias basado en estadismos de generadores (“Inertia/Gobernor Power Flow”)⁶, el cual asume que, después de un disturbio o contingencia, todos los generadores que estén en línea con gobernadores desbloqueados serán ajustados para corregir cualquier excedente o deficiencia de generación de acuerdo con sus estadismos. También se modelaron los banco de capacitores y cambiadores automáticos de “taps” bajo carga. Se aplicó las restricciones de límites de generación de reactivos.

Los casos a analizar son tomados de la Tabla xx, que se repite a continuación:

| CASO | PEORES CONTINGENCIAS N-1 | SIGUIENTE PEOR CONTINGENCIA N-2 CON COLAPSO. | ID | SIGUIENTE PEOR CONTINGENCIA N-2 SIN C.V. | |
|------|--------------------------|--|----|--|----|
| 1 | BERL-SMIG | 15SE-SMIG | 1 | SMIG-OZAT | 16 |

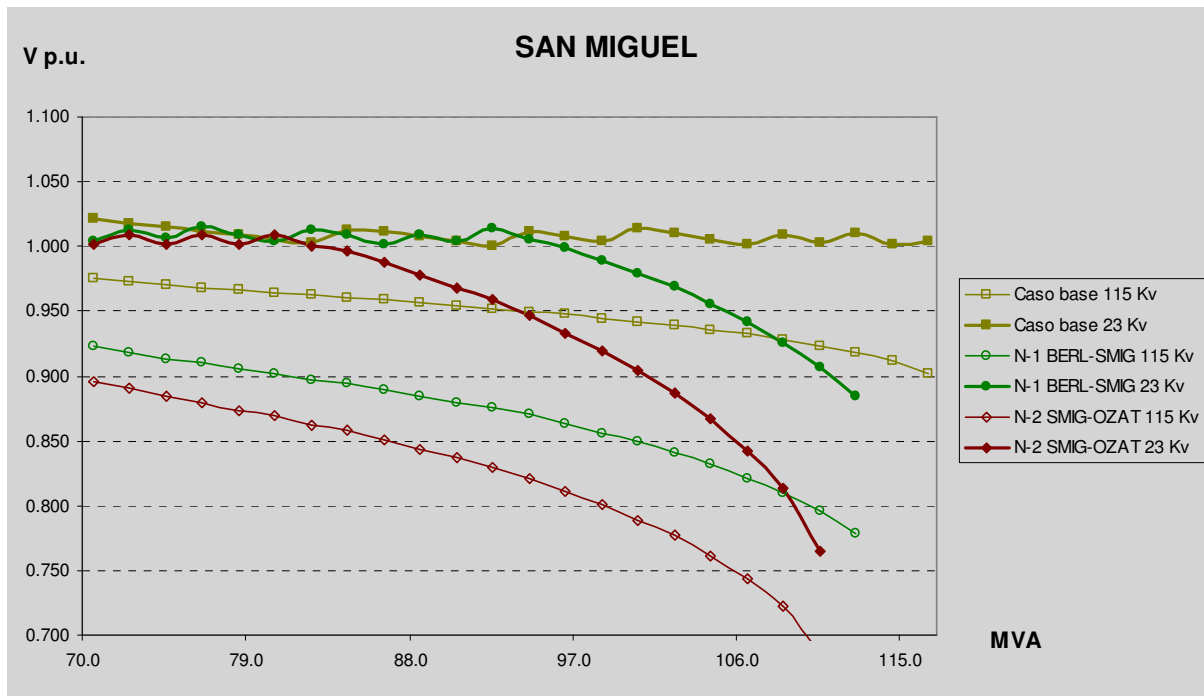
⁶ Pag. 2048, Xiaokang Xu “Assesment of Voltaje Stability and Real and Reactive Margins Using Advanced Analytical Tools”, Documento de Power Technologies Inc (PTI), 2002.

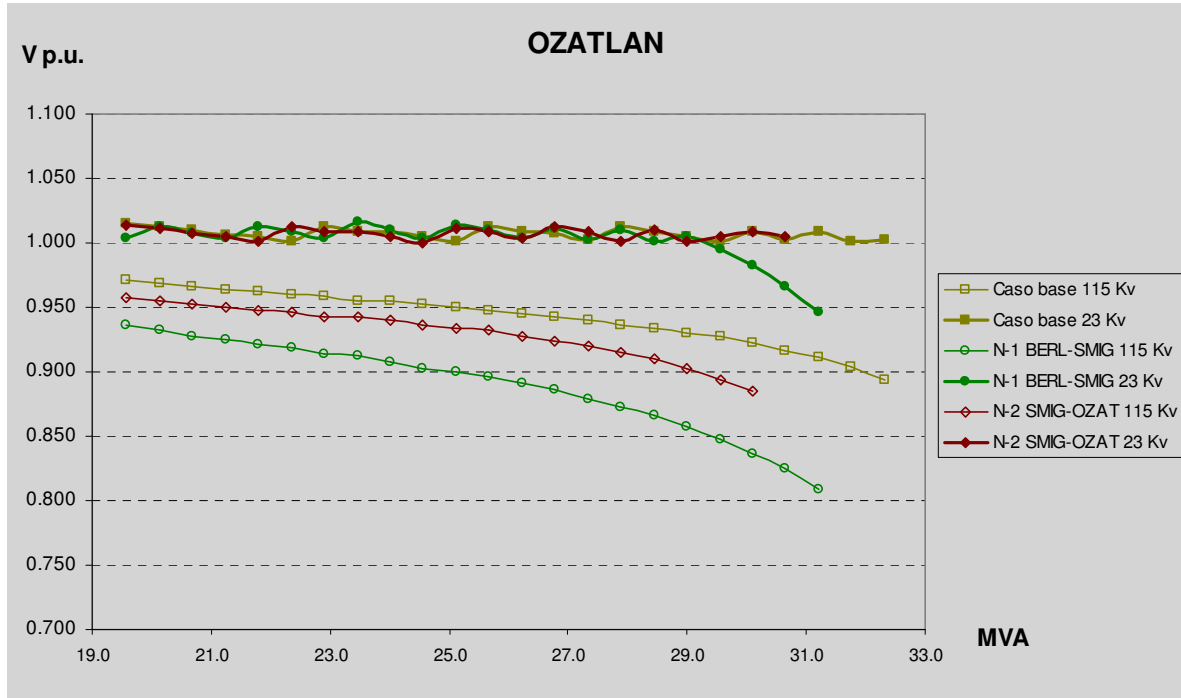
| | | | | | |
|---|-----------|-----------|----|-----------|----|
| | BERL-SMIG | SRAF-TECO | 2 | SMIG-OZAT | 16 |
| | BERL-SMIG | TECO-OZAT | 11 | SMIG-OZAT | 16 |
| 2 | SMAR-STOM | SANT-NEJA | 4 | ACAJ-ATEO | 15 |
| 3 | SRAF-TECO | BERL-SMIG | 2 | 15SE-U1 | 5 |
| 4 | SRAF-TECO | 15SE-SMIG | 3 | NCUS-ATEO | 6 |

Por comparación, además de los casos de la tabla anterior, se ha complementado con los casos no repetidos del escenario de demanda media:

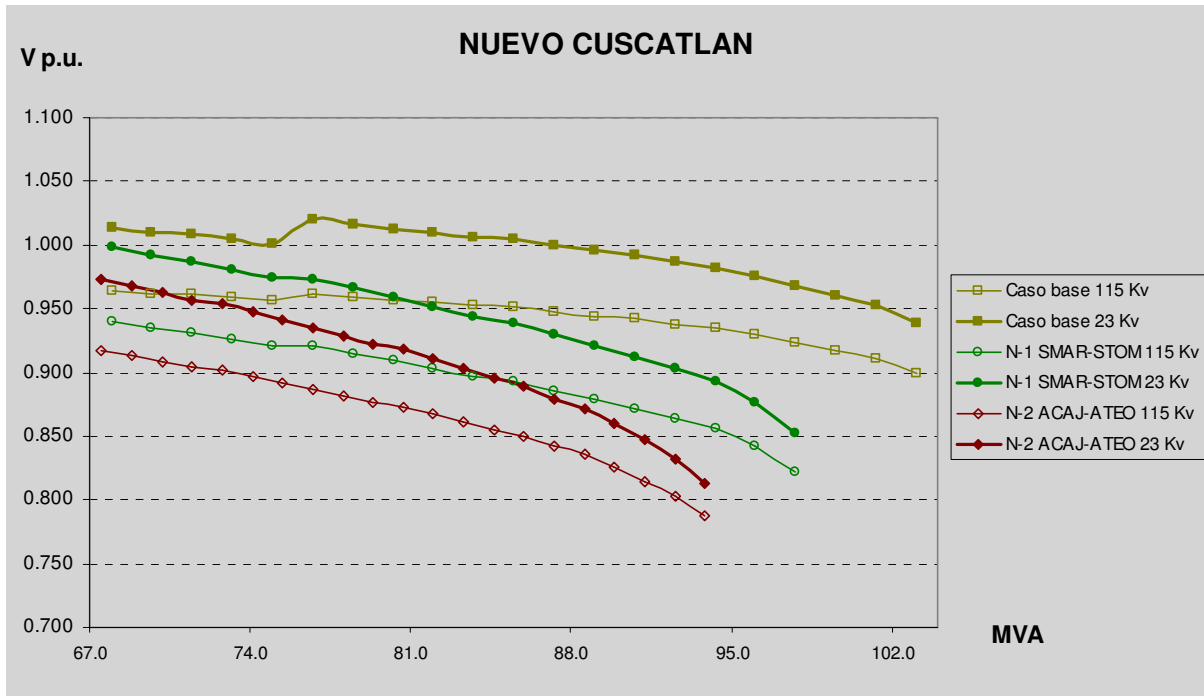
| CASO | PEORES CONTINGENCIAS N-1 | ID | SIGUIENTE PEOR CONTINGENCIA N-2 SIN C.V. | ID |
|------|--------------------------|----|--|----|
| 5 | SMAR-STOM | 1 | ACAJ-U5 | 16 |
| 6 | BERL-SMIG | 2 | 15SE-U1 | 16 |
| 7 | SRAF-TECO | 3 | 15SE-SMIG | 4 |
| 8 | NCUS-ATEO | | SANT-ATEO | 5 |
| 9 | SANT-NEJA | 1 | ACAJ-ATEO | 19 |

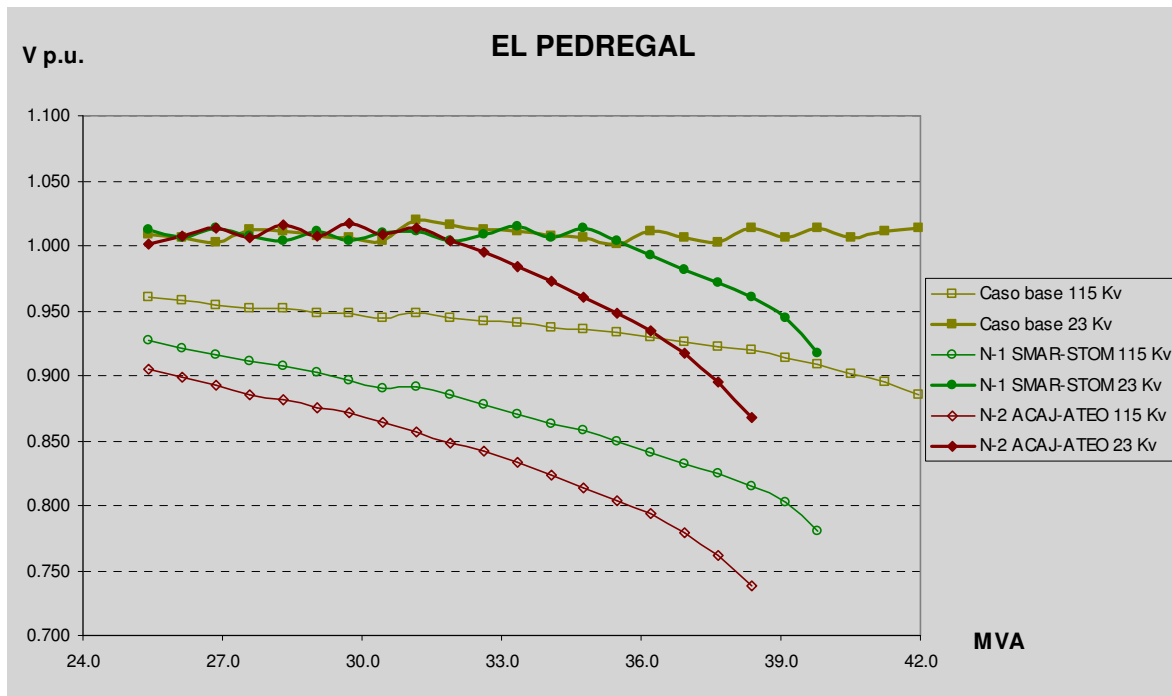
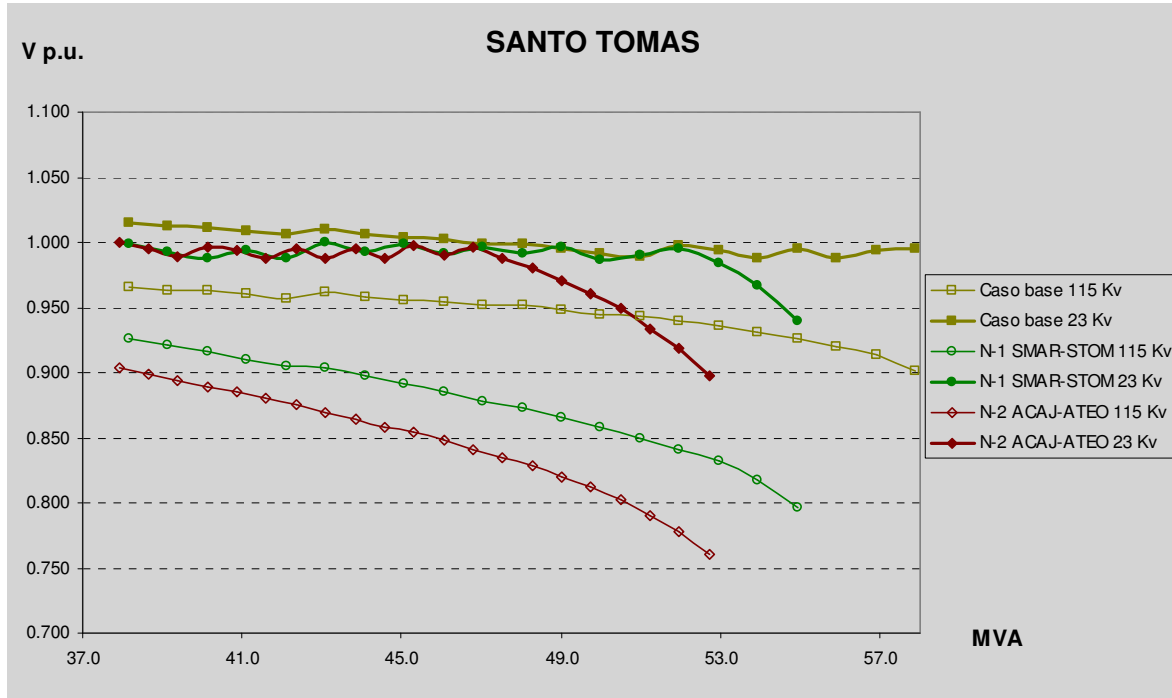
4.4.1. Casos 1,2 y 3: BERL-SMIG & SMIG-OZAT



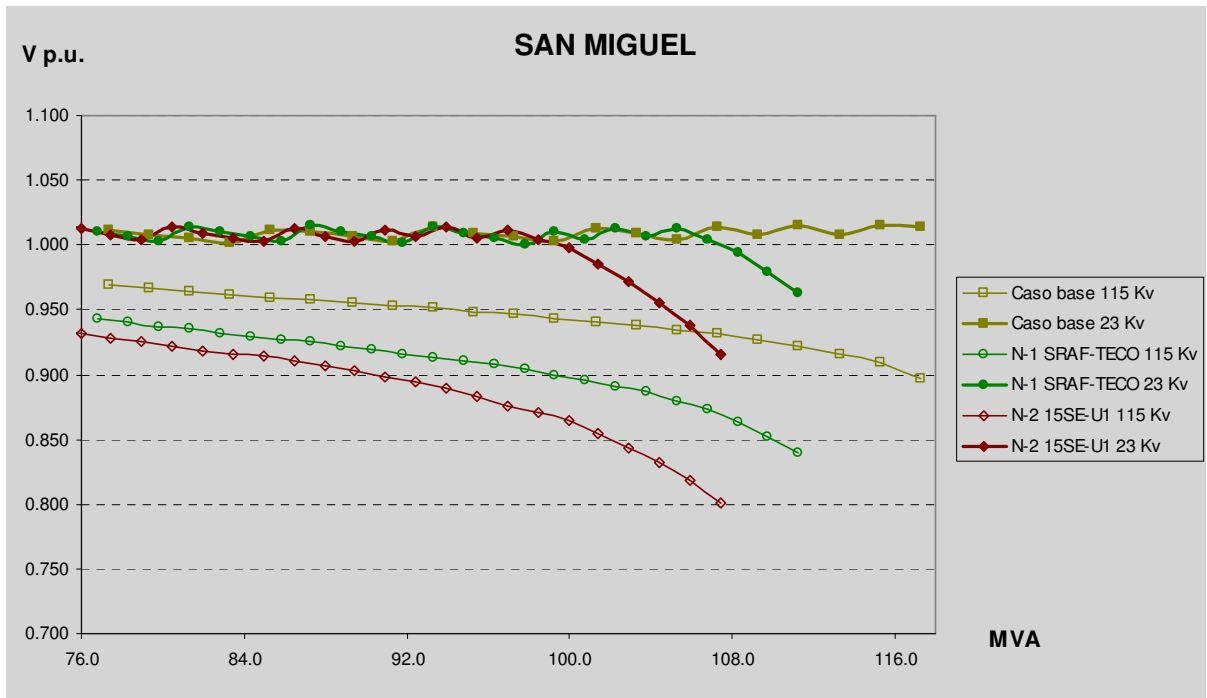
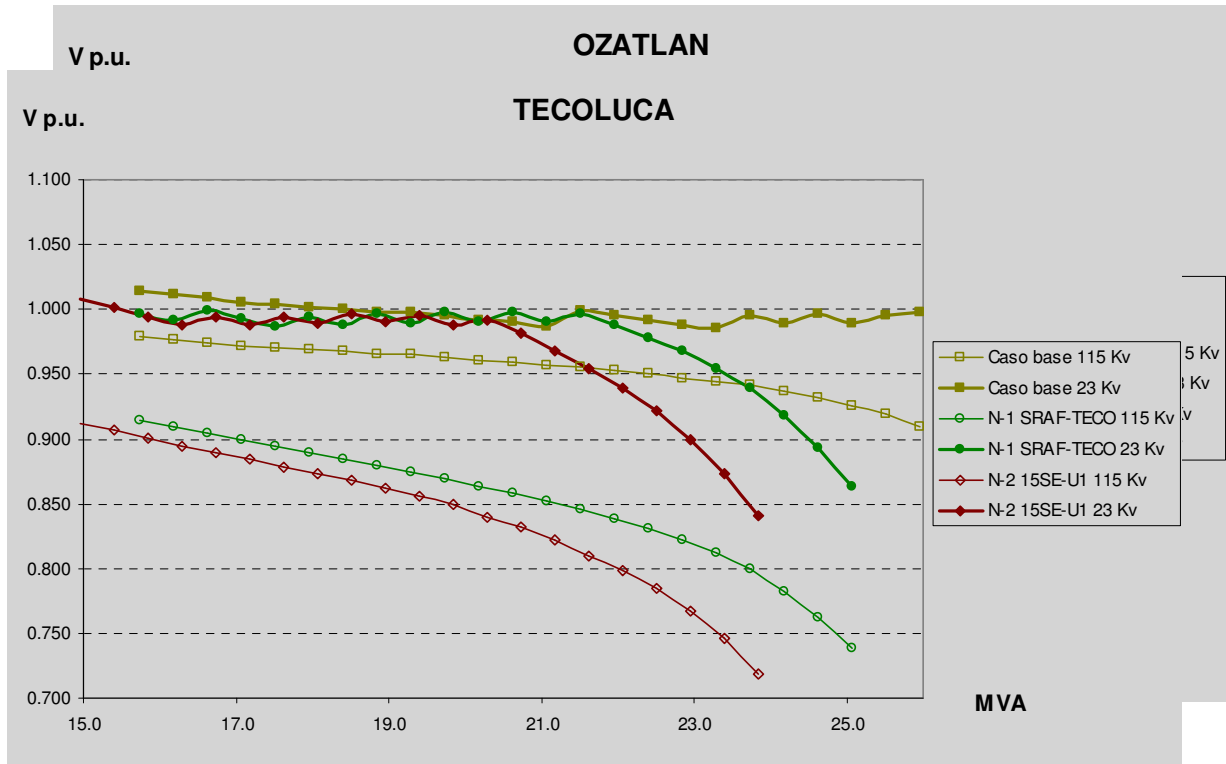


4.4.2. Caso 4: SMAR-STOM & ACAJ-ATEO

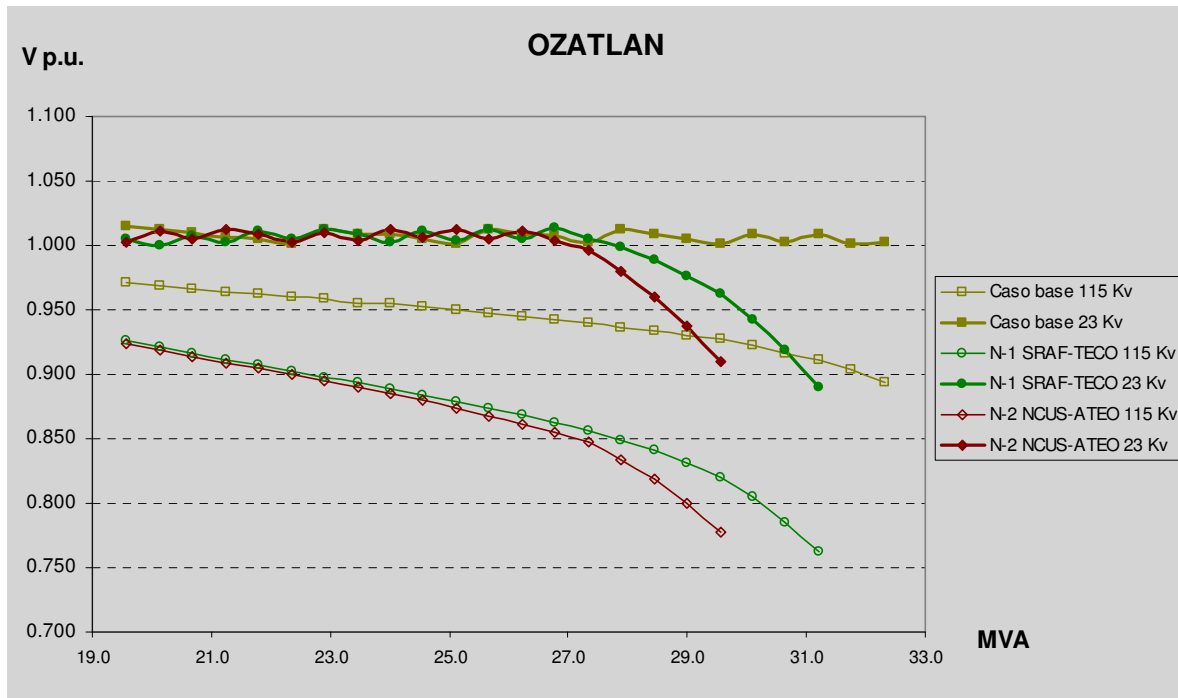
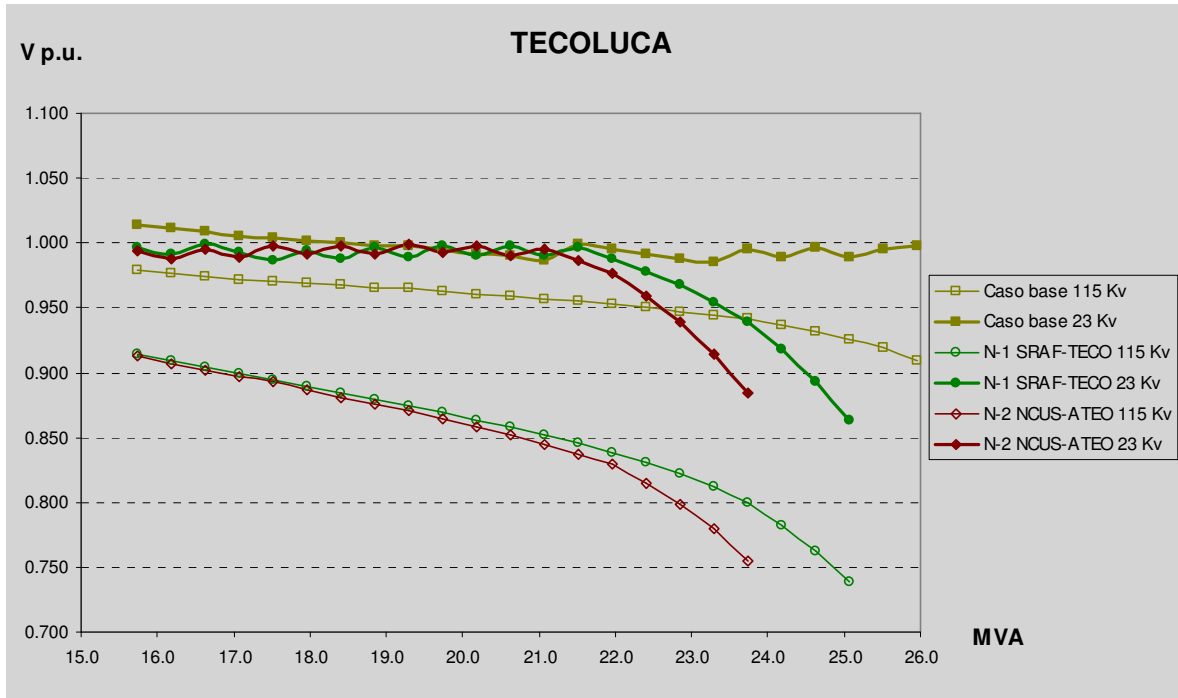


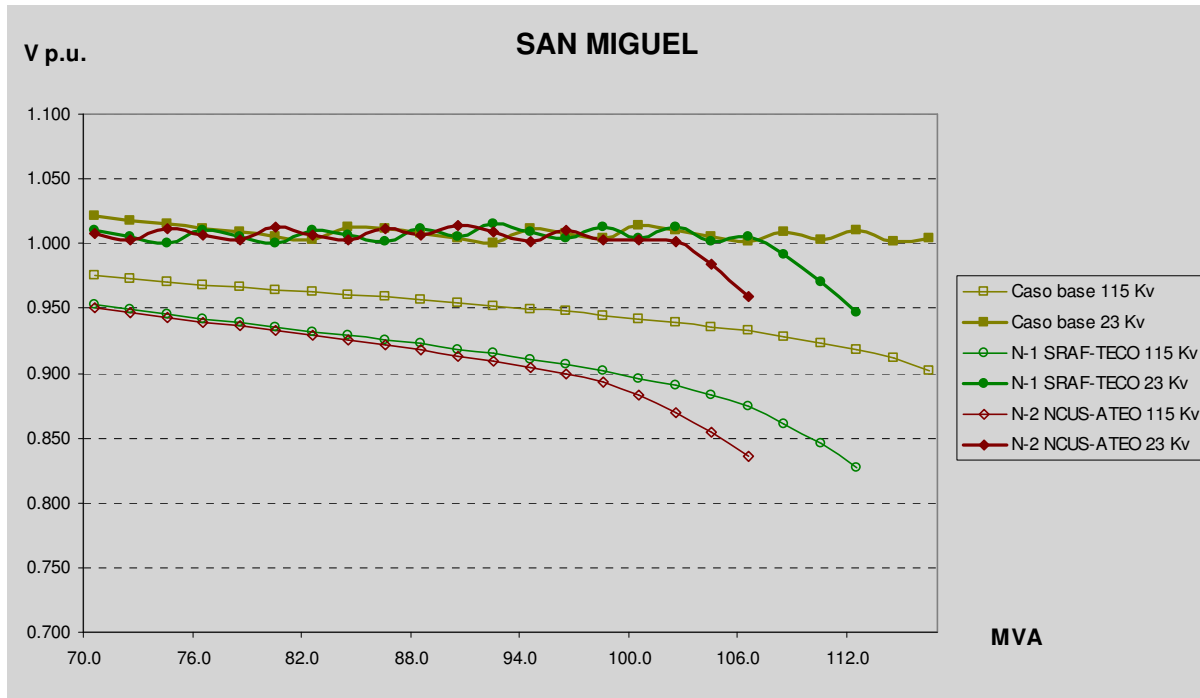


4.4.3. Caso 5: SRAF-TECO & 15SE-U1

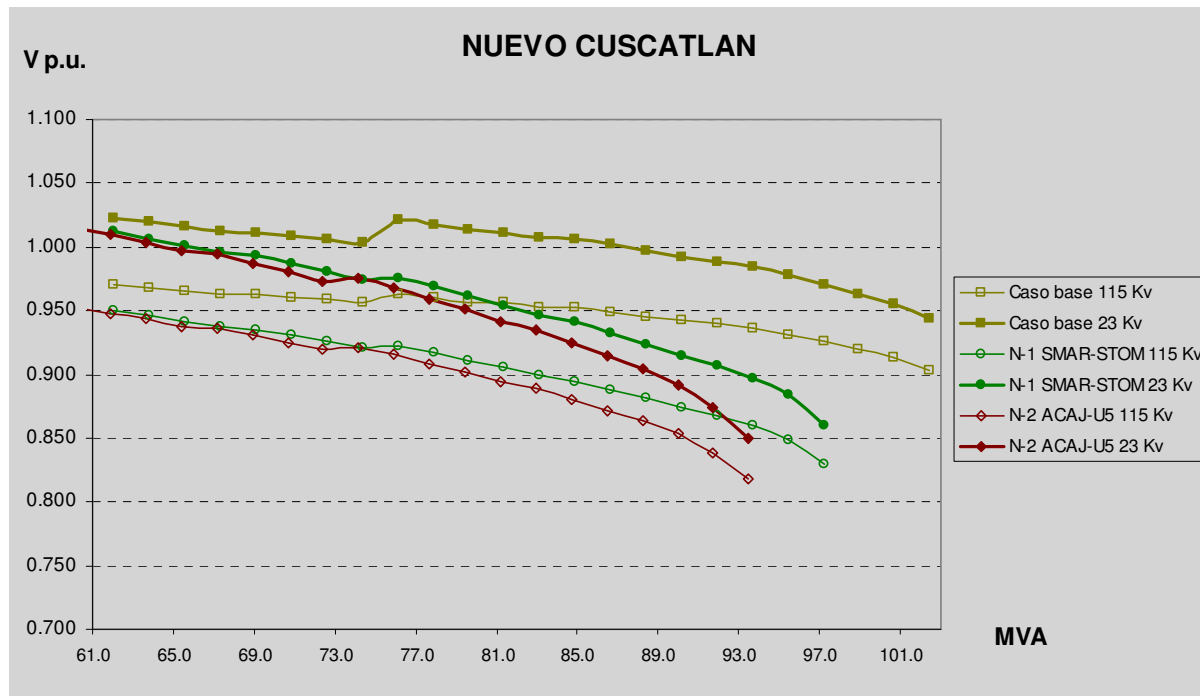


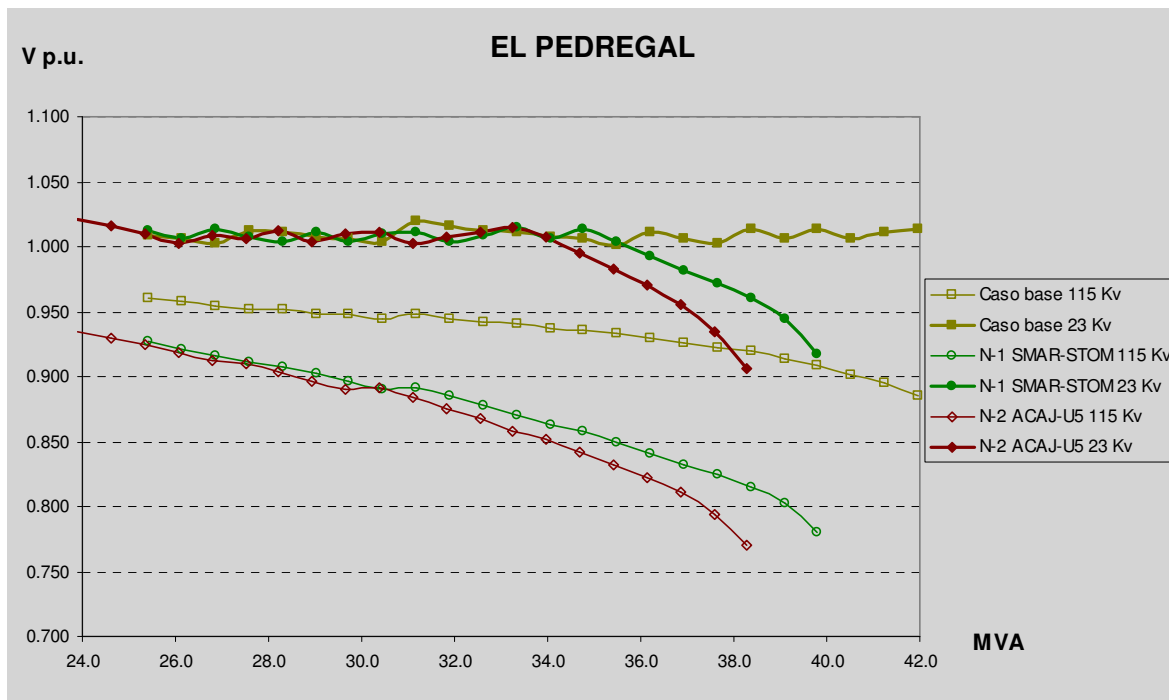
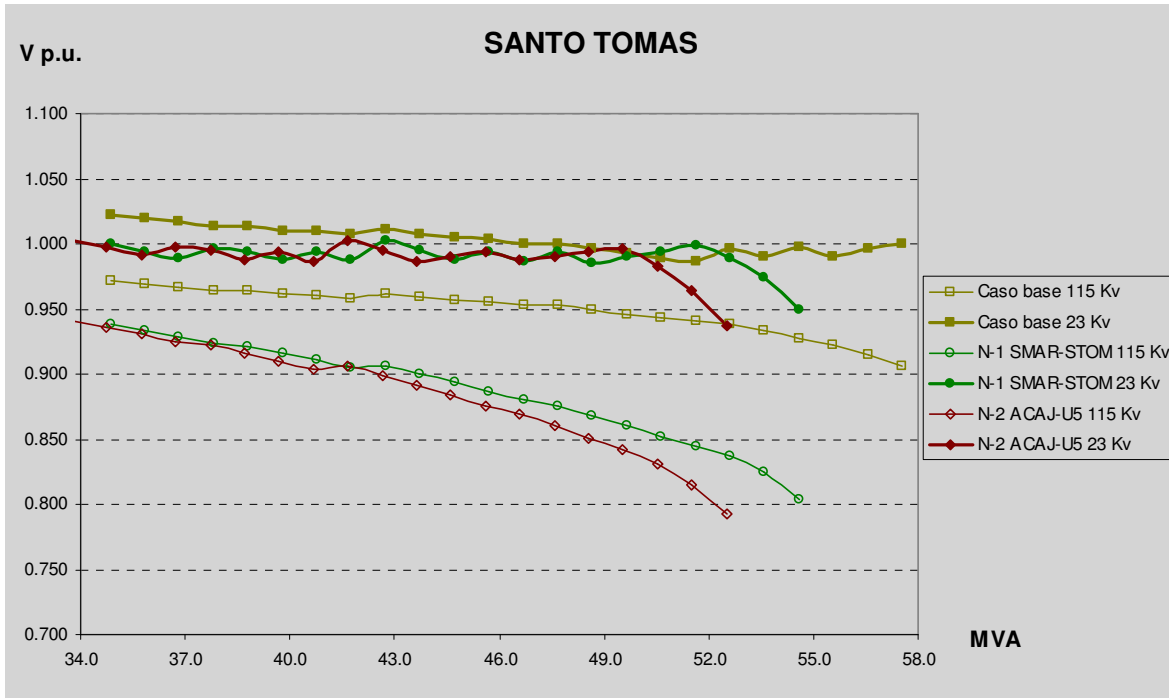
4.4.4. Caso 6: SRAF-TECO & NCUS-ATEO



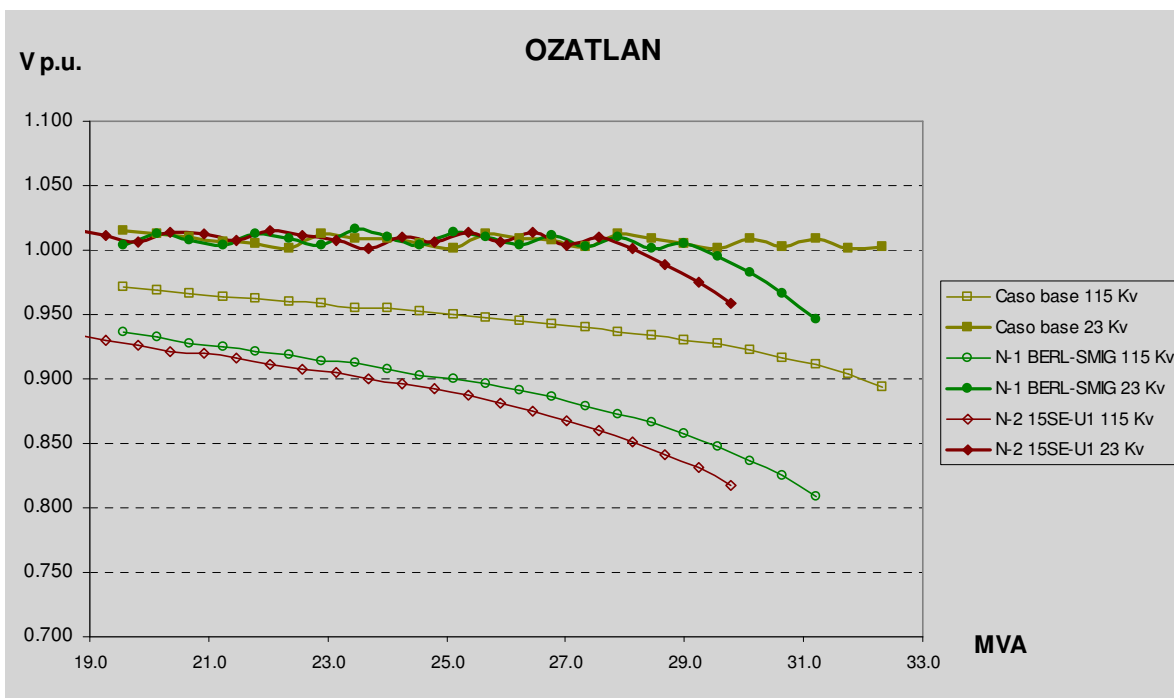
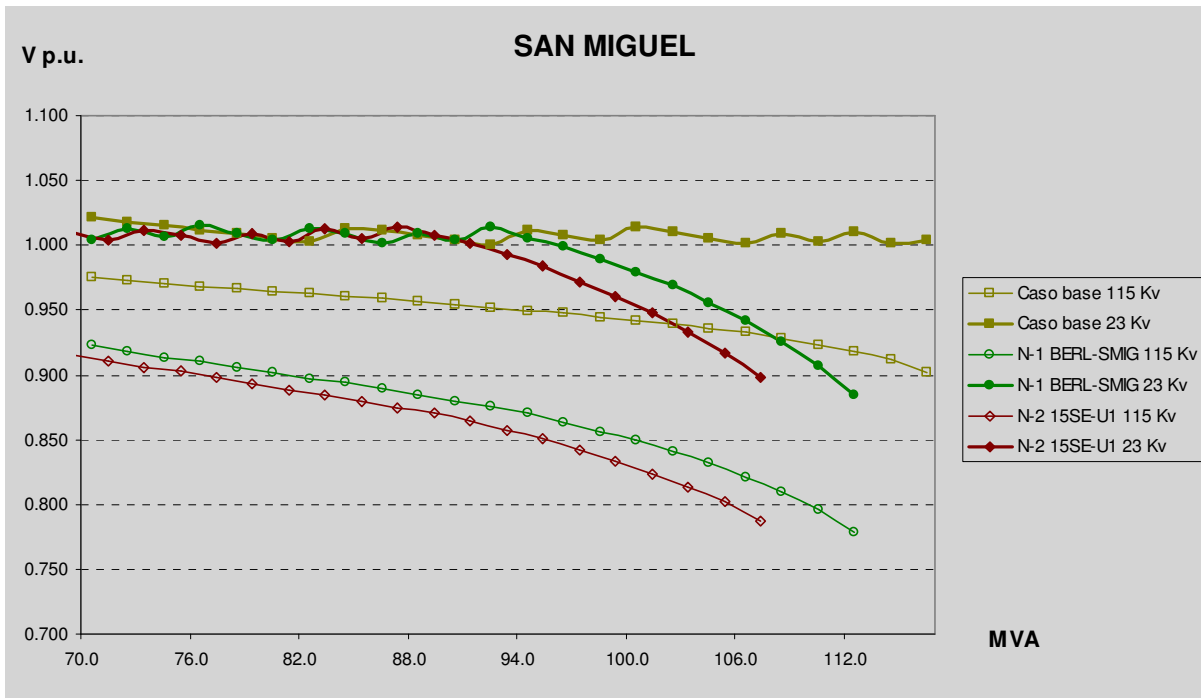


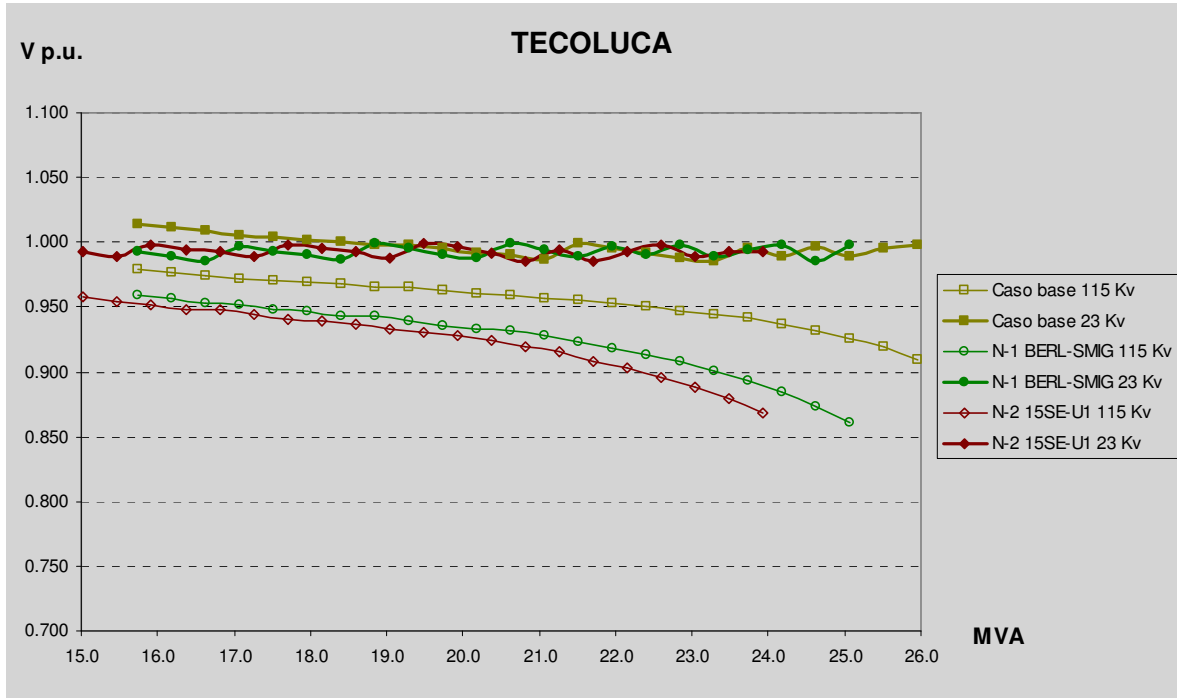
4.4.5. Caso 7: SMAR-STOM & ACAJ-U5



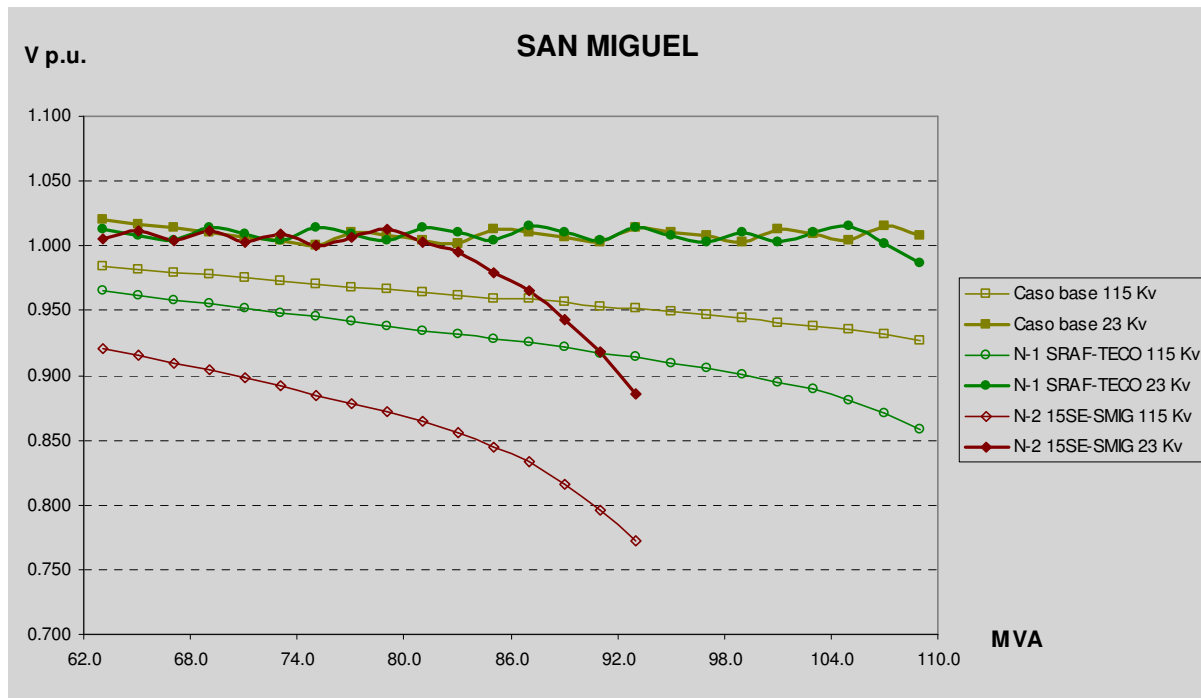


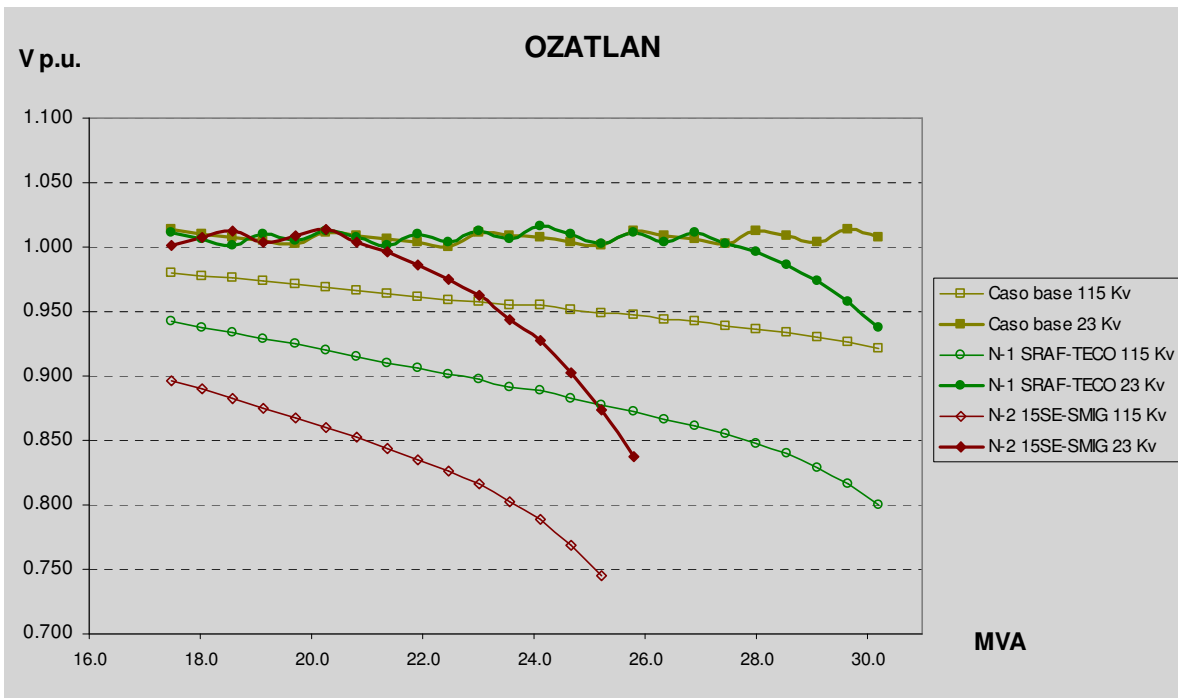
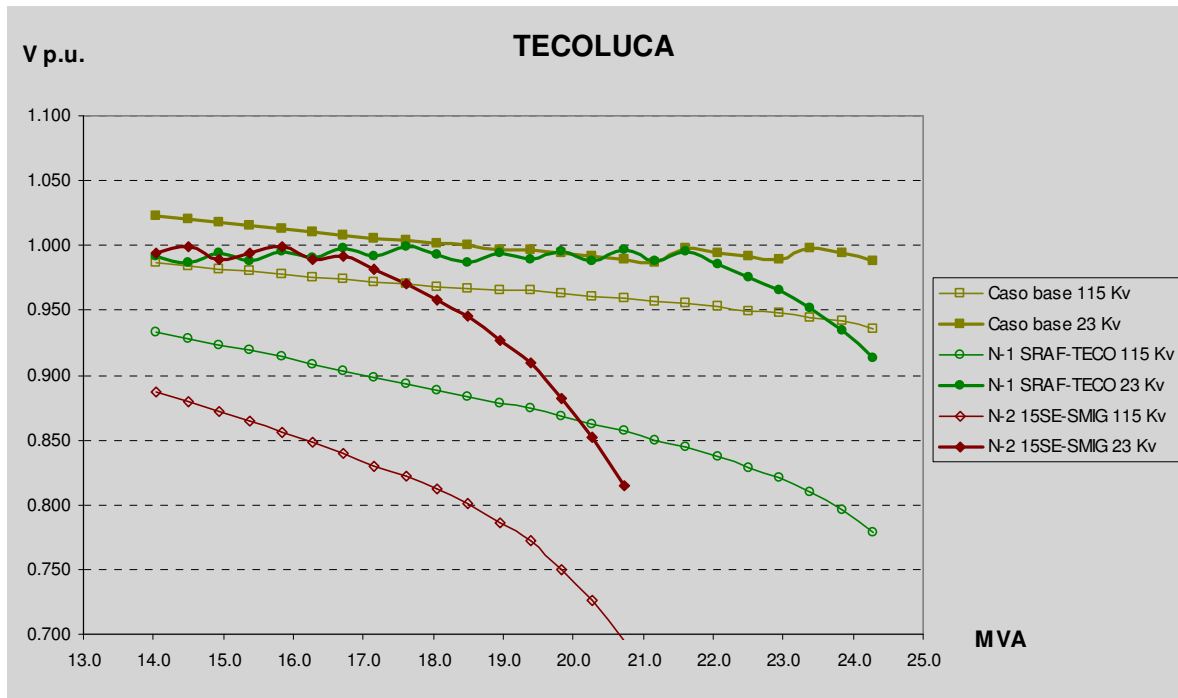
4.4.6. Caso 8: BERL-SMIG Y 15SE-U1



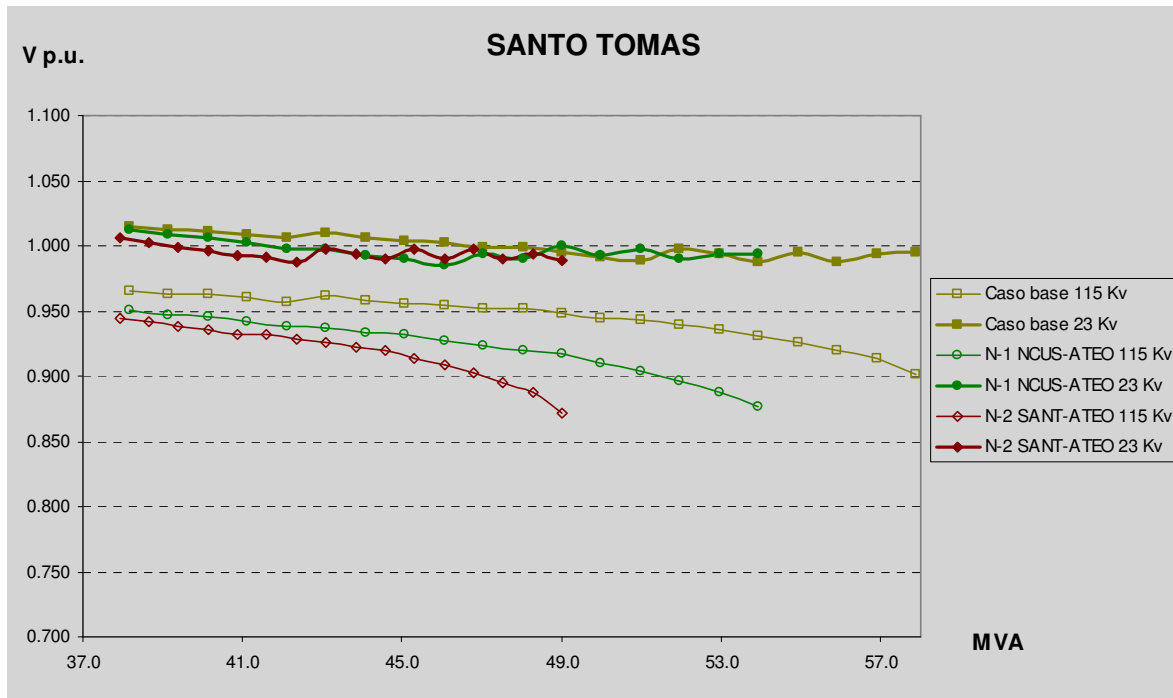
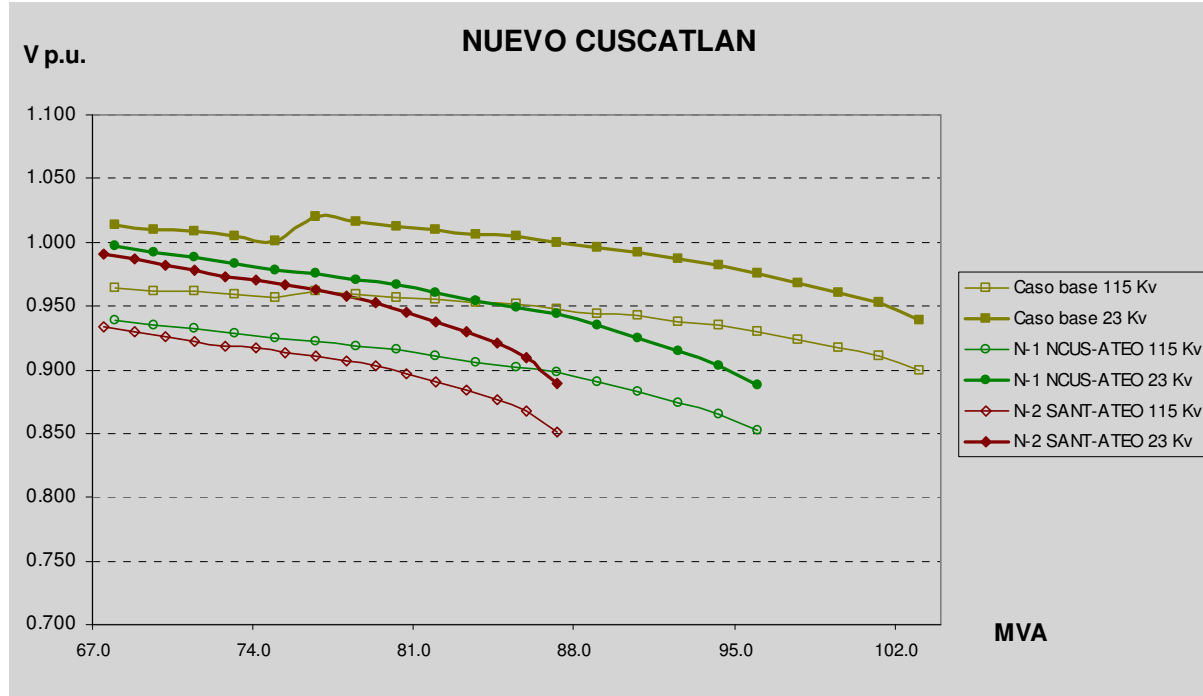


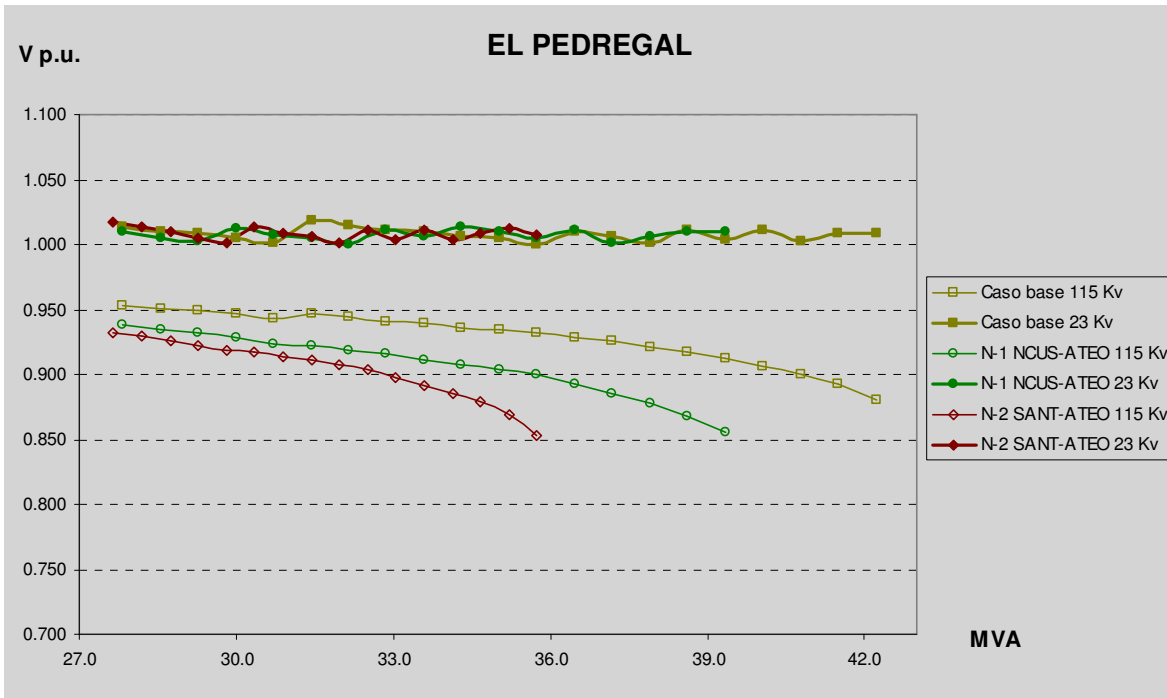
4.4.7. Caso 9: SRAF-TECO & 15SE-SMIG



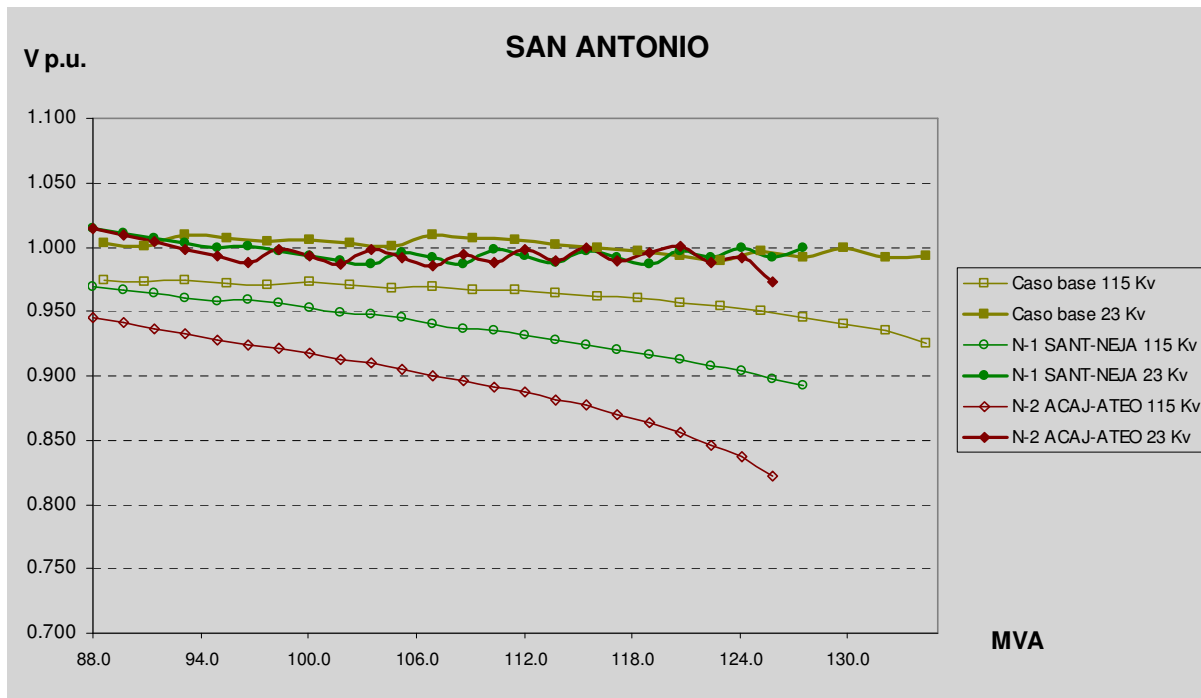


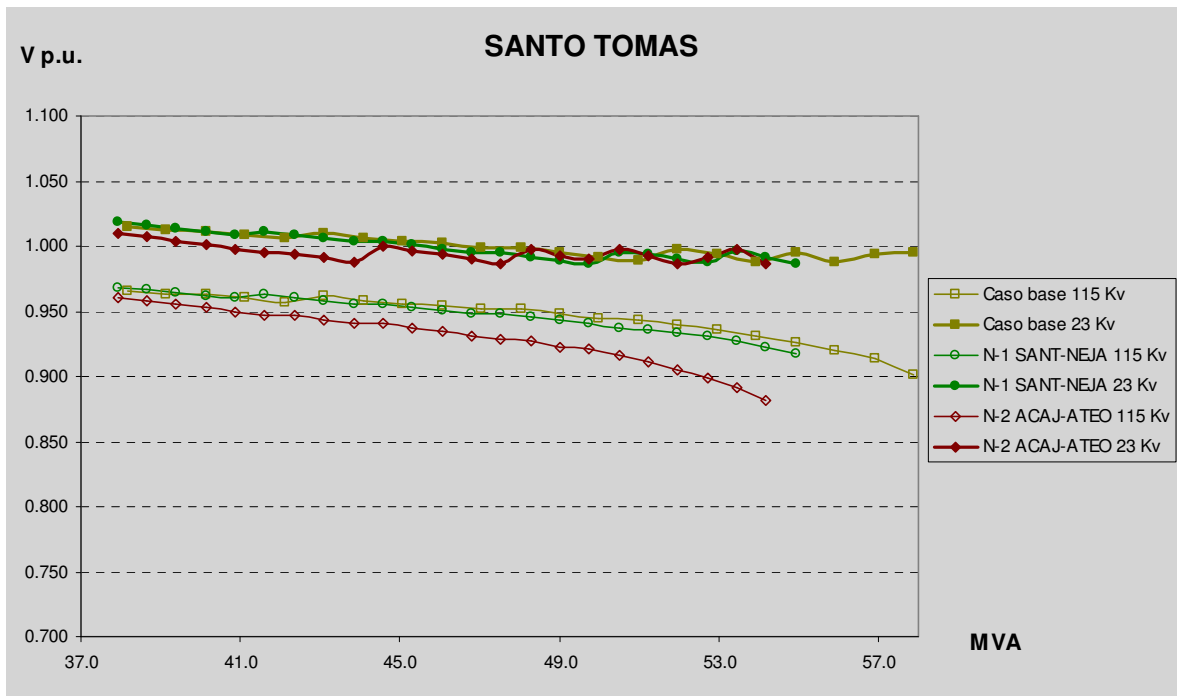
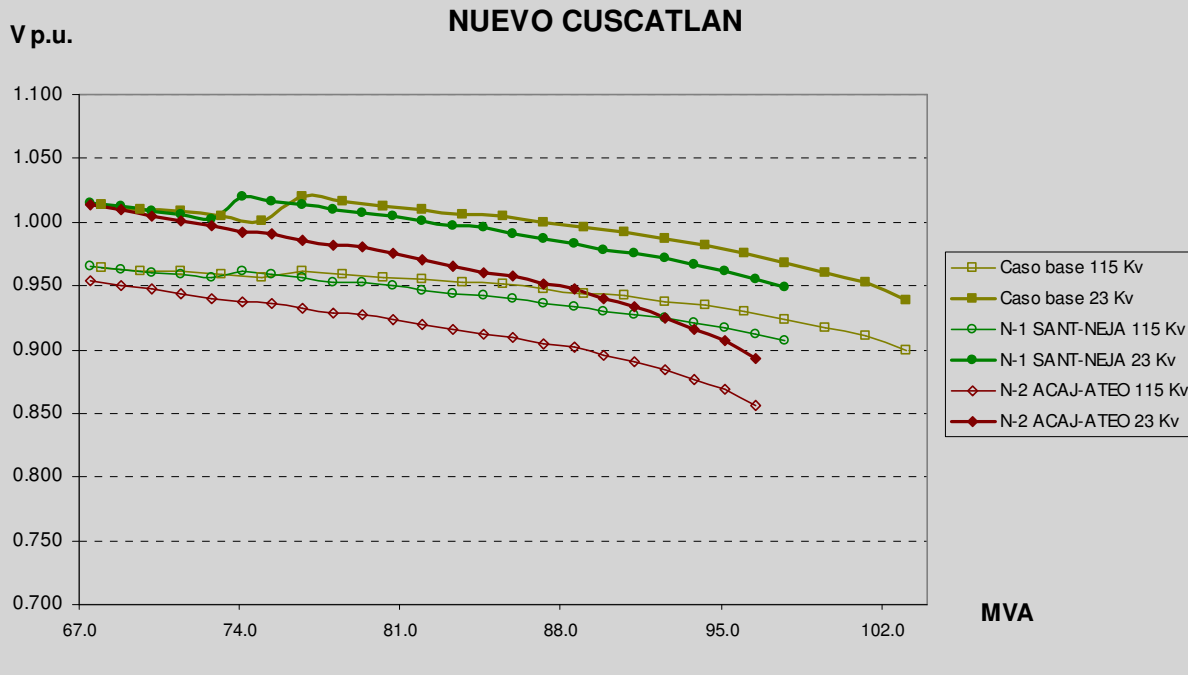
4.4.8. Caso 10: NCUS-ATEO & SANT-ATEO

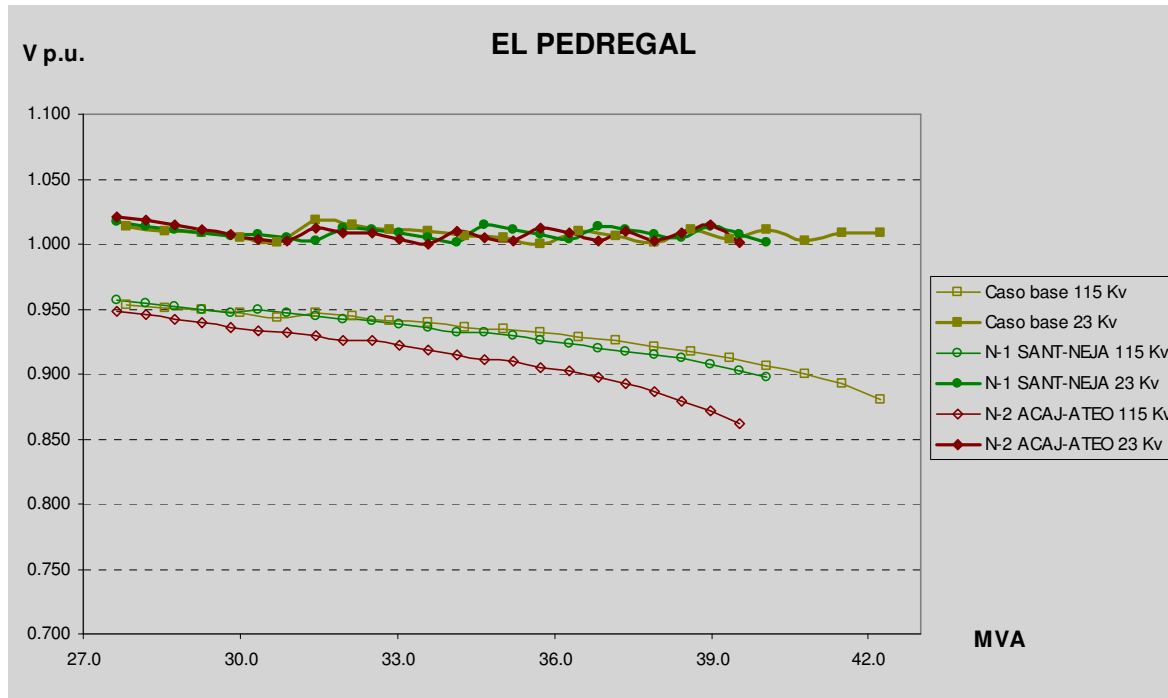




4.4.9. Caso 11: SANT-NEJA & ACAJ-ATEO







4.5. Análisis de ajuste de parámetros iniciales del EDBV

Las siguientes cantidades son identificadas a partir de las curvas P-V para obtener algunos parámetros de ajuste de el esquema de disparo de carga por bajo voltaje:

- Voltaje de inicio para señal de disparo
- Voltaje de recuperación mínimo
- Voltaje de colapso
- Criterio de seguridad
- Margen de operación de disparo
- Margen de operación permitida

| Caso | SUB | Punto de Colapso | | Punto de Recuperación | | | P _{actual} | P _{shed} | Banda de disparo | | | |
|-----------------------|------|------------------|----------------|-----------------------|------------------|----------------|---------------------|-------------------|------------------|------------------|----------------|------------------|
| | | V _{N-1} | P _C | V _{N-1} | V _{N-2} | P _R | | | Inferior | | Superior | |
| | | | | | | | | | P _F | V _{N-1} | P _S | V _{N-1} |
| BERL-SMIG & SMIG-OZAT | SMIG | 0.778 | 113 | 0.923 | 0.896 | 71 | 80 | 9 | 107 | 0.821 | 102 | 0.863 |
| | OZAT | 0.809 | 31 | - | - | - | 22 | - | 29 | 0.857 | - | - |
| SMAR-STOM & ACAJ-ATEO | NCUS | 0.829 | 97 | 0.931 | 0.904 | 71 | 69 | - | 92 | 0.867 | - | - |
| | STOM | 0.803 | 55 | 0.928 | 0.905 | 37 | 41 | 4 | 52 | 0.845 | 48 | 0.875 |
| | PEDR | 0.780 | 40 | 0.927 | 0.905 | 25 | 30 | 5 | 38 | 0.824 | 32 | 0.885 |
| SRAF-TECO & 15SE-U1 | TECO | 0.738 | 25 | 0.915 | 0.901 | 16 | 17 | 1 | 23 | 0.812 | 21 | 0.858 |
| | OZAT | 0.763 | 31 | 0.916 | 0.901 | 21 | 22 | 1 | 29 | 0.831 | 26 | 0.874 |
| | SMIG | 0.827 | 113 | 0.923 | 0.905 | 87 | 80 | - | 107 | 0.874 | 101 | 0.896 |
| SRAF-TECO & NCUS-ATEO | TECO | 0.738 | 25 | 0.910 | 0.907 | 16 | 17 | 1 | 23 | 0.812 | 22 | 0.846 |
| | OZAT | 0.763 | 31 | 0.907 | 0.905 | 22 | 22 | - | 29 | 0.831 | 27 | 0.863 |
| | SMIG | 0.827 | 113 | 0.911 | 0.904 | 95 | 80 | - | 107 | 0.874 | 105 | 0.883 |
| SMAR-STOM & ACAJ-U5 | NCUS | 0.829 | 97 | 0.911 | 0.902 | 80 | 69 | - | 92 | 0.867 | - | - |
| | STOM | 0.803 | 55 | 0.906 | 0.906 | 42 | 41 | - | 52 | 0.845 | 48 | 0.875 |
| | PEDR | 0.780 | 40 | 0.908 | 0.903 | 28 | 30 | 2 | 38 | 0.824 | 33 | 0.87 |
| BERL-SMIG & 15SE-U1 | SMIG | 0.778 | 113 | 0.914 | 0.903 | 75 | 80 | 5 | 107 | 0.821 | 91 | 0.880 |
| | OZAT | 0.809 | 31 | 0.914 | 0.905 | 23 | 22 | - | 29 | 0.857 | 28 | 0.873 |
| | TECO | 0.860 | 25 | 0.918 | 0.903 | 22 | 17 | - | 23 | 0.901 | - | - |
| SRAF-TECO & 15SE-SMIG | SMIG | 0.858 | 109 | 0.955 | 0.904 | 69 | 80 | 11 | 103 | 0.89 | - | - |
| | OZAT | 0.800 | 30 | 0.942 | 0.897 | 17 | 22 | 5 | 28 | 0.847 | 24 | 0.892 |
| | TECO | 0.778 | 24 | 0.933 | 0.887 | 13 | 17 | 4 | 22 | 0.837 | 18 | 0.888 |
| NCUS-ATEO & SANT-ATEO | NCUS | 0.852 | 96 | 0.918 | 0.903 | 78 | 69 | - | 75 | 0.883 | - | - |
| | STOM | 0.876 | 54 | 0.927 | 0.908 | 46 | 41 | - | 51 | 0.903 | - | - |
| | PEDR | 0.856 | 39 | 0.918 | 0.904 | 32 | 30 | - | 37 | 0.885 | - | - |
| SANT-NEJA & ACAJ-ATEO | SANT | 0.892 | 128 | 0.945 | 0.905 | 105 | 91 | - | 121 | 0.912 | - | - |
| | NCUS | 0.907 | 98 | 0.936 | 0.905 | 87 | 69 | - | 93 | 0.924 | - | - |
| | STOM | 0.918 | 55 | 0.943 | 0.923 | 49 | 41 | - | 52 | 0.933 | - | - |
| | PEDR | 0.898 | 40 | 0.926 | 0.906 | 36 | 30 | - | 38 | 0.914 | - | - |