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# **Updated Detailed Powerflow Study Results**

**Presentation for STEP Group 10/2/2003**

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- Preliminary results were presented to the STEP Group on August 28<sup>th</sup>
- Several updates received by various parties
- Study focused on the 6 preferred STEP alternatives: 4 AC and 2 DC
- Peak and Off-Peak conditions studied
  - Peak; A summer peak day in the 2007-08 timeframe
  - Off-peak; late November, 2008, in the afternoon.
- Analysis of lower voltage transmission system included ( $> 100$  kV)



## What the study included:

- Normal overloads (N-0)
- All single (N-1) contingencies (lines and transformers) 100 kV and above
- All credible double (N-2) contingencies 230 kV and above and G-2
- Post Transient voltage deviations (5% criteria for single contingencies and 10 % for double contingencies)

Study area covered Arizona, Nevada, CFE Mexico and S. California)



## Updates

- Placed the series capacitor at Mohave on the Mohave – Lugo 500 kV line in service (total compensation on the line is 70%)
- Updated the N-1 rating on Blythe – Knob 161 kV line (600 A)
- Upgraded the system West of Devers pr. SCE recommendation; Included the reconductoring to 2B-1033 ACSR of the 4 230 kV lines west of Devers (AC alternatives only)
- Removed Devers – Mira Loma 500 kV line in all alternatives



## Updates cont.

- Added load at SCE's new Viejo 230 kV Substation
- Added the Salton Sea Unit 6 (185 MW) pr. IID recommendation including several transmission upgrades:
  - Replaced the 125 MVA 161/92kV bank at Coachella Valley with a 225 MVA bank
  - Replaced the 75 MVA 161/92kV bank at Niland with a 225 MVA bank
  - Installed a parallel 125 MVA 161/92kV bank at Avenue 58
- IID Generation was re-dispatched to accommodate the new generation



## Updates cont.

- 4 Capacitor banks were added to 69 kV system in the Yuma area (APS):
  - 25.2 MVAR at Yucca West
  - 28.8 MVAR at Laguna
  - 2 x 28.2 MVAR at Foothills
- Removed 460 MW generation in CFE's system (off-peak case only) to better match the economic study results
- Updated the N-1 rating on two LADWP transformers pr. LADWP recommendation
  - Victorville 500/287 kV transformer
  - Toluca No. 1 500/230 kV transformer



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# Results



## **Series capacitors upgrade common to all 6 alternatives**

- Hassayampa – North Gila 500 kV line
- North Gila – Imperial Valley 500 kV line
- Imperial Valley – Miguel 500 kV line
- Palo Verde – Devers 500 kV line
- Navajo – Crystal 500 kV line (not needed in DC-2)



## **Identified N-0 & N-1 overloads common to all 6 of the alternatives**

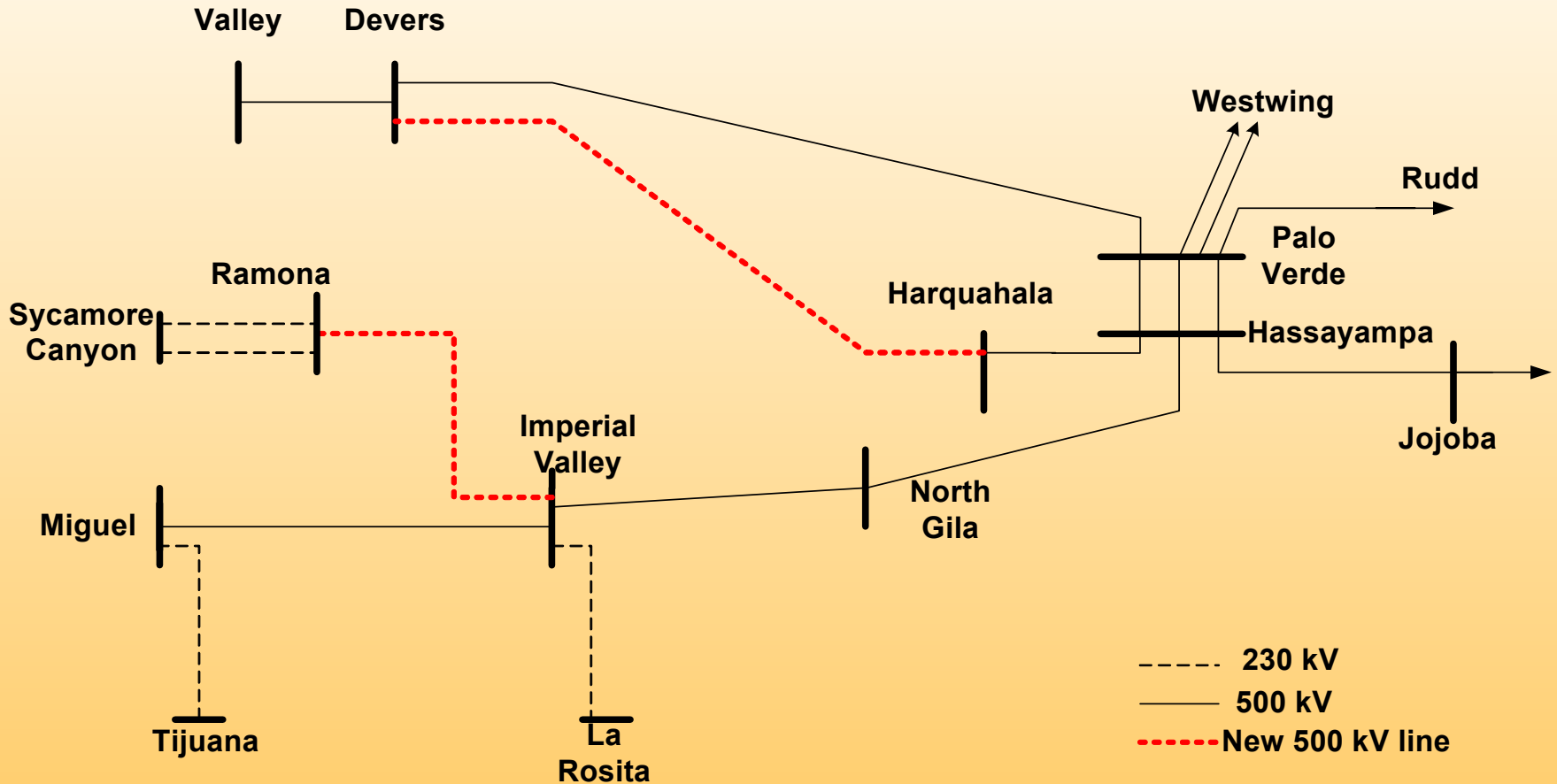
- North and West of Miguel Substation due to high Miguel Import (N-0, N-1) SDG&E
- 230 kV lines parallel to Imperial Valley - Miguel 500 kV line (N-1) CFE
- Thunderstone – Santan 230 kV line (N-1) SRP
- Mirage – Tamarisk 115 kV line (N-0, N-1) SCE
- Imperial Valley 500/230 kV 600 MVA transformer (T-1) SDG&E
- Sycamore Canyon (N-0, N-1) SDG&E (not overloaded in AC-2)



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## AC-1





## Specific normal & single contingency overloads AC1

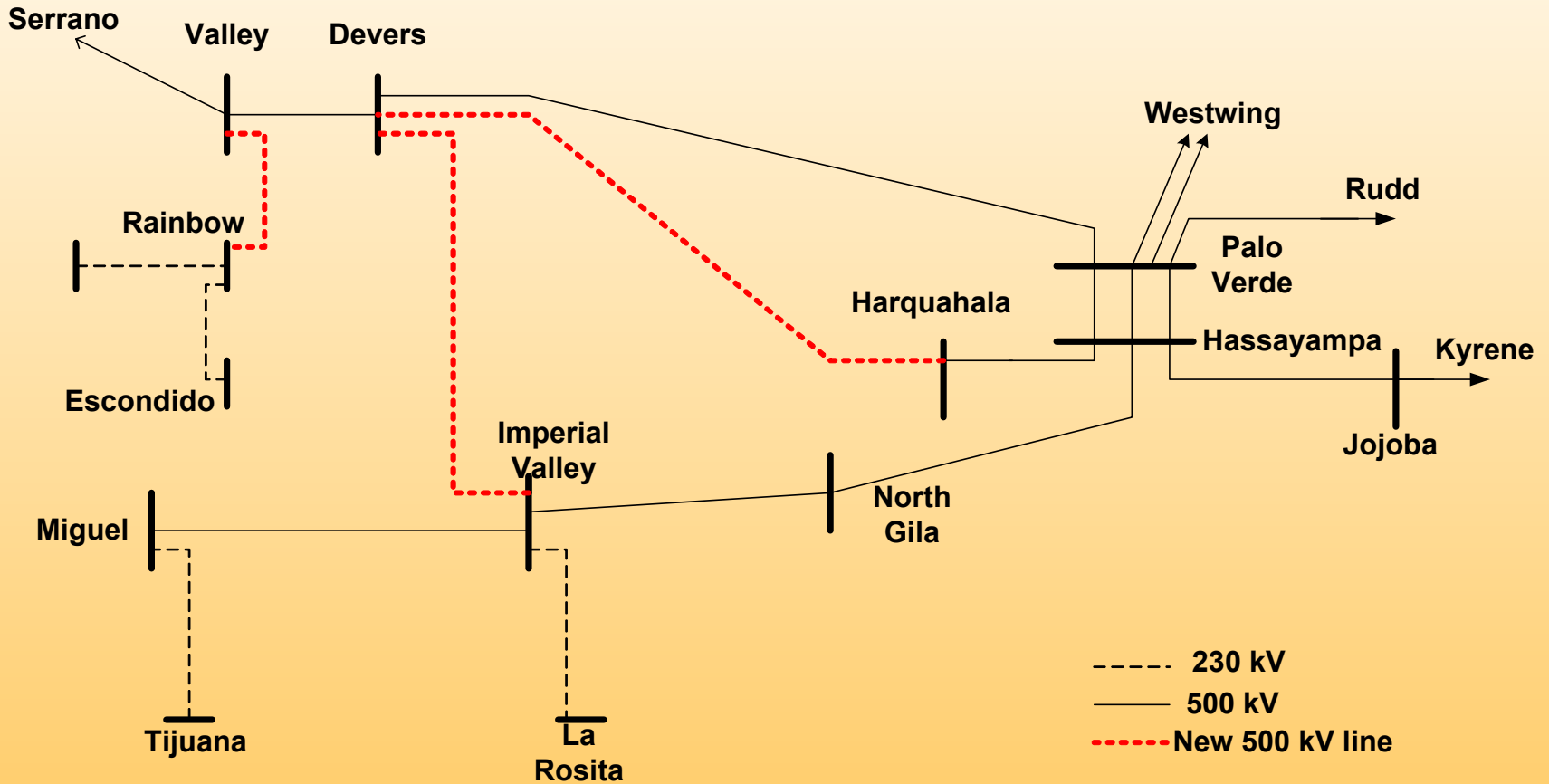
- Loss of Hassayampa – North Gila 500 kV line overloads Blythe – Knob 161 kV line and the Yucca and Gila 161/69 kV transformers
- Loss of North Gila – Imperial Valley 500 kV line overloads Blythe – Niland 161 kV line (existing SPS in place to trip generation at Blythe for this outage)
- Loss of Camino – Iron Mountain 230 kV line overloads Blythe – Eagle Mountain 161 kV line
- Loss of one 500/230 kV transformer bank at either Miguel or Devers overloads the parallel bank above the long term emergency rating



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## AC-2





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## Specific normal & single contingency overloads AC2

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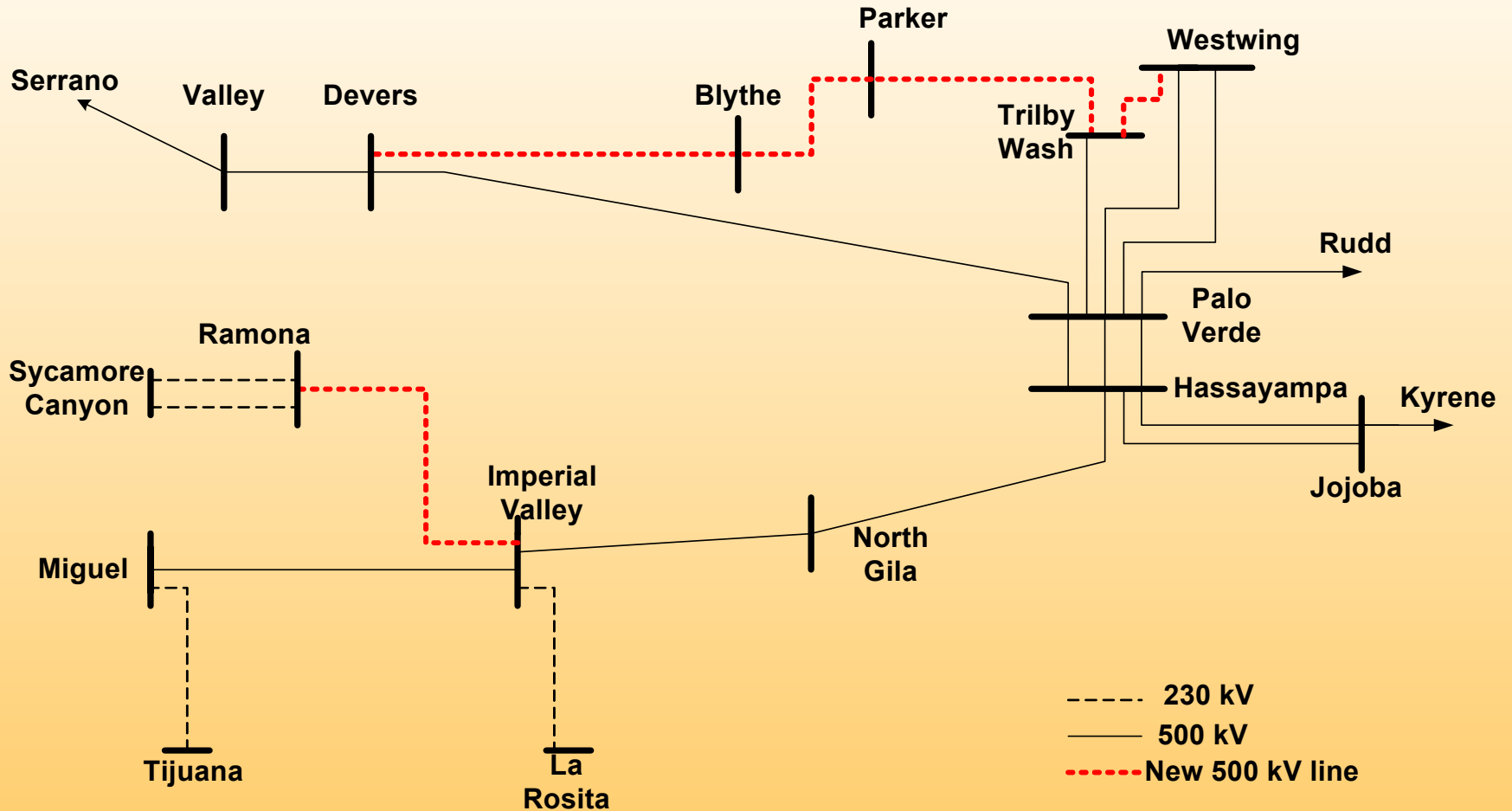
- Loss of Hassayampa – North Gila 500 kV line overloads Blythe – Knob 161 kV line
- Loss of Blythe – Blythe SC 161 kV line overloads Blythe – Niland 161 kV line
- Loss of Camino – Iron Mountain 230 kV line overloads Blythe – Eagle Mountain 161 kV line
- Loss of one 500/230 kV transformer bank at either Miguel or Devers overloads the parallel bank above the long term emergency rating



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## AC-3





## Specific normal & single contingency overloads AC3

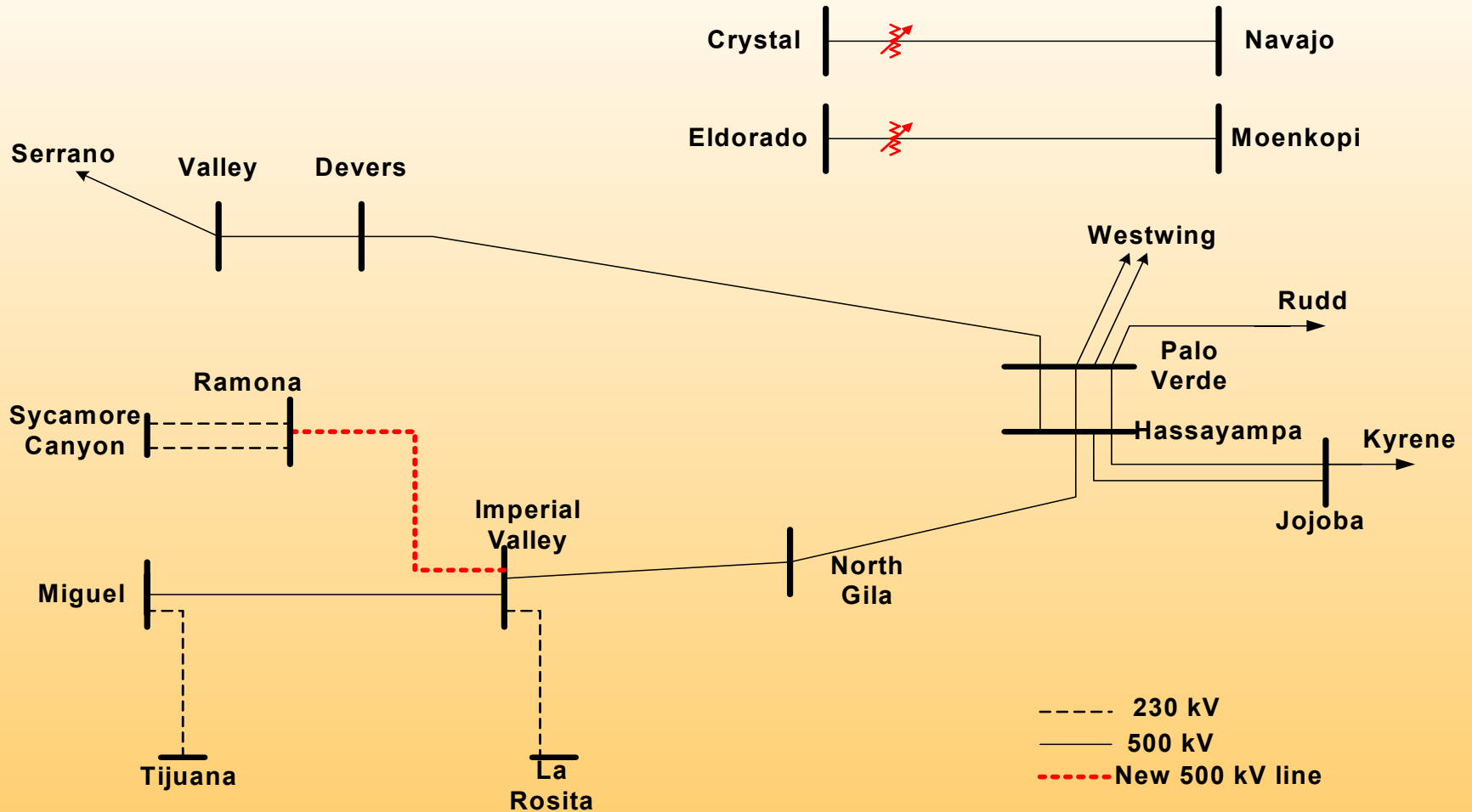
- Loss of Hassayampa – North Gila 500 kV line overloads Blythe – Knob 161 kV line and the Yucca and Gila 161/69 kV transformers
- Loss of one 500/230 kV transformer bank at either Miguel or Devers overloads the parallel bank above the long term emergency rating
- Emergency overload on Moenkopi – Eldorado 500 kV series capacitors



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## AC-4





## Specific normal & single contingency overloads AC4

- Normal and single contingency overload on Blythe – Eagle Mountain and Blythe - Knob 161 kV lines
- Loss of Hassayampa – North Gila 500 kV line overloads Yucca and Gila 161/69 kV transformers
- Loss of North Gila – Imperial Valley 500 kV line overloads Blythe – Niland 161 kV line (existing SPS in place to trip generation at Blythe for this outage)
- Loss of Camino – Iron Mountain 230 kV line overloads Blythe – Eagle Mountain 161 kV line
- Loss of one 500/230 kV transformer bank at Miguel overloads the parallel bank above the long term emergency rating



## Specific normal & single contingency overloads AC4 cont.

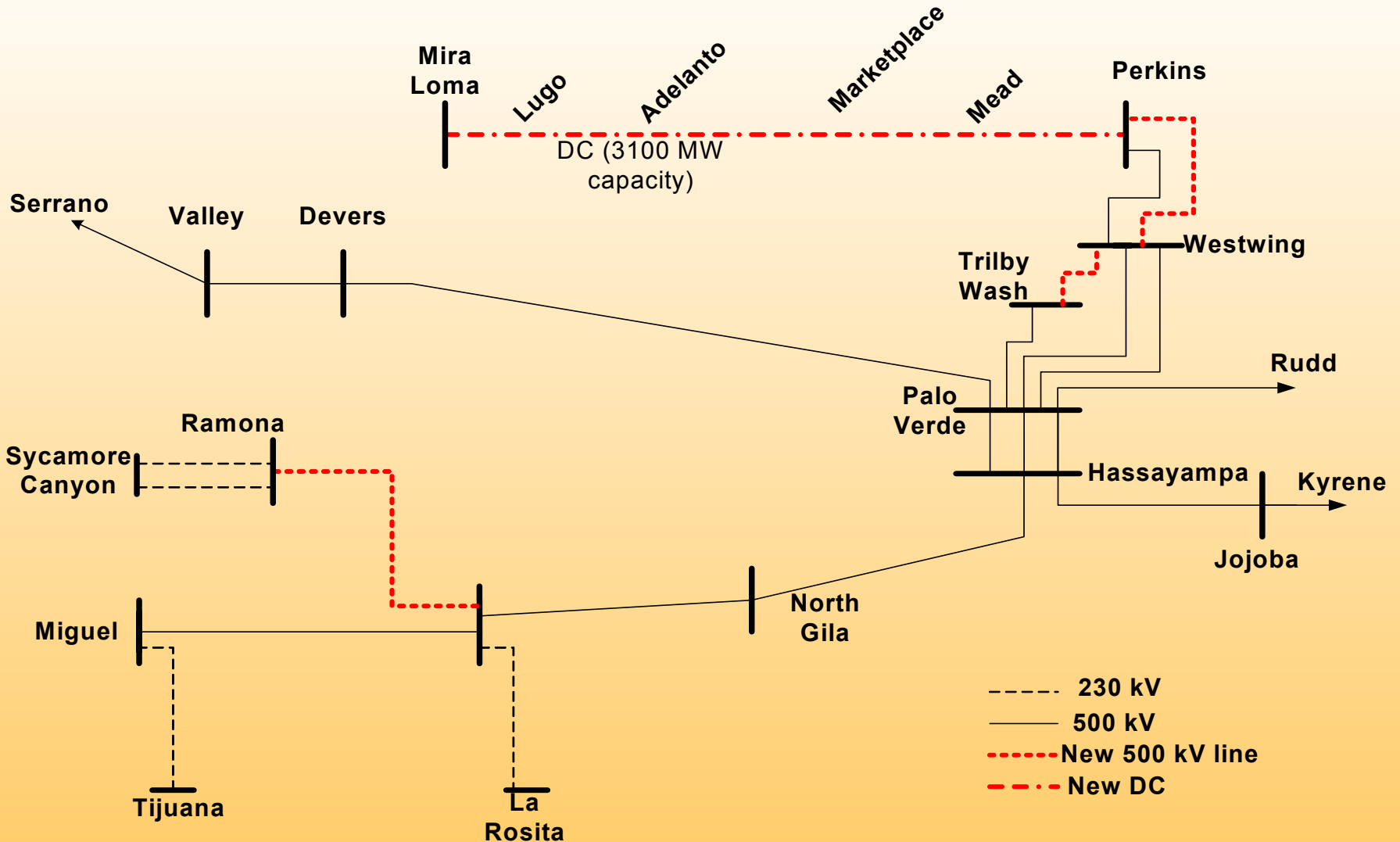
- Loss of Palo Verde – Devers 500 kV line overloads Banister – Avenue 58 161 kV line
- Loss of Eldorado – Lugo or Mohave – Lugo 500 kV line overloads terminal equipment on Victorville – Lugo 500 kV line
- Need to replace series capacitors on Moenkopi – Eldorado and Perkins - Mead 500 kV lines



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## DC-1



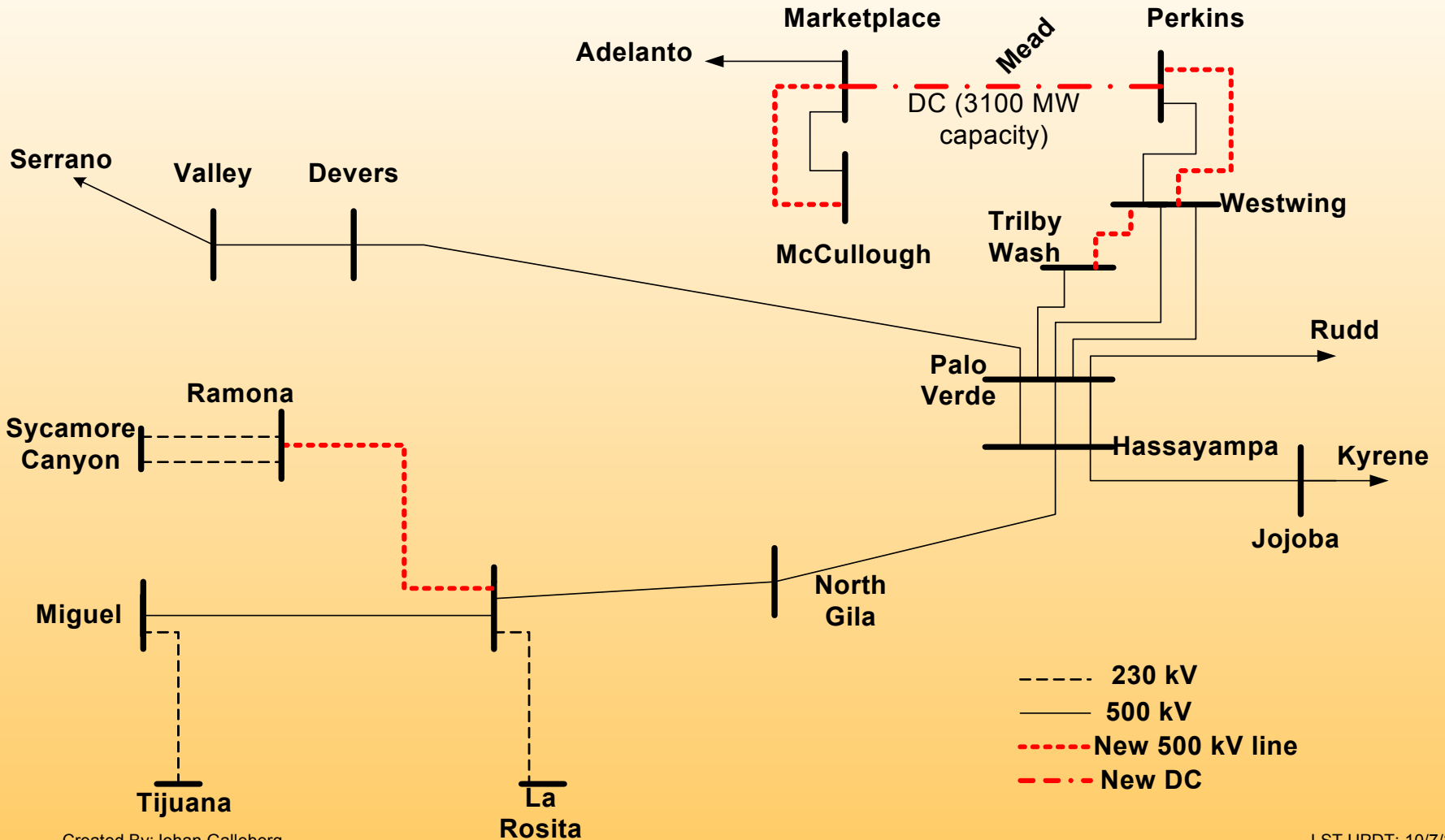


## Specific normal & single contingency overloads DC1

- Loss of Hassayampa – North Gila 500 kV line overloads Blythe – Knob 161 kV line and the Yucca 161/69 kV transformers
- Loss of North Gila – Imperial Valley 500 kV line overloads Blythe – Niland 161 kV line (existing SPS in place to trip generation at Blythe for this outage)
- Loss of Camino – Iron Mountain 230 kV line overloads Blythe – Eagle Mountain 161 kV line
- Loss of Devers – Valley 500 kV line overloads the Devers 500/230 kV transformer bank above the long term emergency rating



## DC-2





## Specific normal & single contingency overloads DC2

- Normal and single contingency overload on Blythe – Eagle Mountain and Blythe - Knob 161 kV lines
- Loss of Hassayampa – North Gila 500 kV line overloads Yucca and Gila 161/69 kV transformers
- Loss of North Gila – Imperial Valley 500 kV line overloads Blythe – Niland 161 kV line (existing SPS in place to trip generation at Blythe for this outage)
- Loss of Camino – Iron Mountain 230 kV line overloads Blythe – Eagle Mountain 161 kV line



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## Specific normal & single contingency overloads DC2 cont.

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- Loss of one 500/230 kV transformer bank at Miguel overloads the parallel bank above the long term emergency rating
- Loss of Devers – Valley 500 kV line overloads Devers 500/230 kV transformer above the long term emergency rating
- Loss of Palo Verde – Devers 500 kV line overloads Banister – Avenue 58 161 kV line and the Liberty 230 kV phase shifter



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## Specific normal & single contingency overloads DC2 cont.

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- Loss of Eldorado – Lugo or Mohave – Lugo 500 kV line overloads terminal equipment on Victorville – Lugo 500 kV line
- Loss of either Ramon – Mirage 230 kV line or Coachella Valley 230 kV line overloads the other line
- Loss of the Toluca No. 2 500/230 kV transformer overloads Toluca No.1 500/230 kV transformer
- Need to replace series capacitors on Eldorado – Lugo and Mohave - Lugo 500 kV lines



## Double contingency analysis (N-2)

- Loss of Palo Verde - Devers & Harquahala (Blythe) – Devers 500 kV lines overload (no load & gen. dropping):
  - Perkins – Mead 500 kV series capacitors (AC1, AC2, AC3)
  - Perkins 500 kV Phase shifters (AC1, AC2, AC3)
  - Liberty 230 kV Phase shifter (AC1)
  - Avenue 58 – Banister 161 kV (AC1, AC3)
  - Hassayampa – North Gila – Imperial Valley 500 kV series capacitors (AC1, AC2, AC3)
  - Blythe - Eagle Mountain 161 kV line (AC1, AC3)
  - Parker – Gene 230 kV line (AC3)
  - Several 161 kV lines out of Blythe (AC3)



## Double contingency analysis (N-2)

- Loss of Lugo – Mira Loma No. 2 or No. 3 and Lugo - Serrano 500 kV lines overload (no load & gen. dropping):
  - Line conductor Lugo – Mira Loma No. 2 (AC4, DC2)
  - Line conductor Lugo – Mira Loma No. 3 (AC4, DC2)



## Double contingency analysis (N-2)

- Loss of Palo Verde – Westwing No. 1 & 2 500 kV lines overload (no load & gen. dropping):
  - Rudd # 1, 2 & 3 500/230 kV transformers (AC4)
  - Trilby Wash 500/230 kV transformer (AC4)
  - White Tank – Rudd 230 kV line (AC4)
  - Jojoba – Kyrene 500 kV line (AC4)



## Double contingency analysis (N-2)

- Loss of new DC line overloads (no load & gen. dropping):
  - Liberty 230 kV Phase shifter (DC1, DC2)
  - Blythe – Eagle Mountain 161 kV line (DC2)



## Extreme contingency analysis Devers Substation (NERC/WECC Category D)

- Loss of all transmission lines in a common right-of-way
- Loss of substation (one voltage level + transformers)



## Extreme contingency analysis Devers

### Substation (AC1)

- No additional voltage support is needed to sustain the loss of Palo Verde – Devers & Harquahala - Devers 500 kV lines during peak, however, additional voltage support is needed at Miguel & Eldorado during off-peak (~600 MVAR)
- Loss of the four 230 kV lines west of Devers did not identify any violations (peak/off-peak)
- Additional voltage support is needed to sustain the loss of all 6 230 kV lines and the loss of the two 500/230 kV transformers (peak/off-peak)
- No additional voltage support is needed to sustain the loss of all three 500 kV lines and the two 500/230 kV transformers during peak, however, additional voltage support is needed during off-peak



## Summary Thermal Overloads

	AC1	AC2	AC3	AC4	DC1	DC2
<b>Overloads at Sycamore Canyon</b>	<b>N-0, N-1</b>	<b>-</b>	<b>N-0, N-1</b>	<b>N-0, N-1</b>	<b>N-0, N-1</b>	<b>N-0, N-1</b>
<b>Overload Blythe – Knob 161 kV</b>	<b>N-1</b>	<b>N-1</b>	<b>N-1</b>	<b>N-0, N-1</b>	<b>N-1</b>	<b>N-0, N-1</b>
<b>Overload of Banister – Avenue 58 161 kV</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>N-1</b>	<b>-</b>	<b>N-1</b>
<b>Overload of Liberty phase shifter</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>N-1</b>
<b>Overload of Blythe – Eagle Mountain 161 kV</b>	<b>N-1</b>	<b>N-1</b>	<b>-</b>	<b>N-0, N-1</b>	<b>N-1</b>	<b>N-0, N-1</b>
<b>Overload of Blythe – Niland 161 kV</b>	<b>N-1</b>	<b>N-1</b>	<b>-</b>	<b>N-1</b>	<b>N-1</b>	<b>N-1</b>
<b>Overload on Devers – Valley 500 kV</b>	<b>-</b>	<b>N-1</b>	<b>-</b>		<b>-</b>	<b>-</b>
<b>Overload of Yucca 161/69 kV transformers</b>	<b>N-1</b>	<b>-</b>	<b>N-1</b>	<b>N-1</b>	<b>N-1</b>	<b>N-1</b>
<b>Overload of Gila 161/69 kV transformers</b>	<b>N-1</b>	<b>-</b>	<b>N-1</b>	<b>N-1</b>	<b>-</b>	<b>N-1</b>
<b>Overload of Toluca No.1 500/230 kV transformer</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>N-1</b>
<b>Overload of Ramon – Mirage 230 kV</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>N-1</b>	<b>N-1</b>
<b>Overload of Coachella Valley – Devers 230 kV</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>N-1</b>
<b>Overload of Merchant – Eldorado 230 kV</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>N-1</b>
<b>Overload of Victorville – Lugo 500 kV</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>N-1</b>	<b>-</b>	<b>N-1</b>
<b>Overload of Devers No.1 or 2 500/230 kV transformer</b>	<b>T-1</b>	<b>T-1</b>	<b>T-1</b>	<b>-</b>	<b>N-1</b>	<b>N-1</b>
<b>Overload of Miguel No.1 or 2 500/230 kV transformer</b>	<b>T-1</b>	<b>T-1</b>	<b>T-1</b>	<b>T-1</b>	<b>-</b>	<b>T-1</b>



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## Summary Series Capacitor Upgrades

	AC1	AC2	AC3	AC4	DC1	DC2
<b>Hassayampa – North Gila 500 kV</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>North Gila – Imperial Valley 500 kV</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>Imperial Valley – Miguel 500 kV</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>Palo Verde – Devers 500 kV</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>Navajo – Crystal 500 kV</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	-
<b>Moenkopi – Eldorado 500 kV</b>	-	-	<b>X</b>	<b>X</b>	-	-
<b>Perkins – Mead 500 kV</b>	-	-	-	<b>X</b>	-	-
<b>Eldorado – Lugo 500 kV</b>	-	-	-	-	-	<b>X</b>
<b>Mohave – Lugo 500 kV</b>	-	-	-	-	-	<b>X</b>



## MVAR requirement for each alternative (ballpark numbers)

