STEP Dynamic Stability Study Results

Short-term Upgrades

Sensitivities and Development of a Replacement for the SCIT Nomogram

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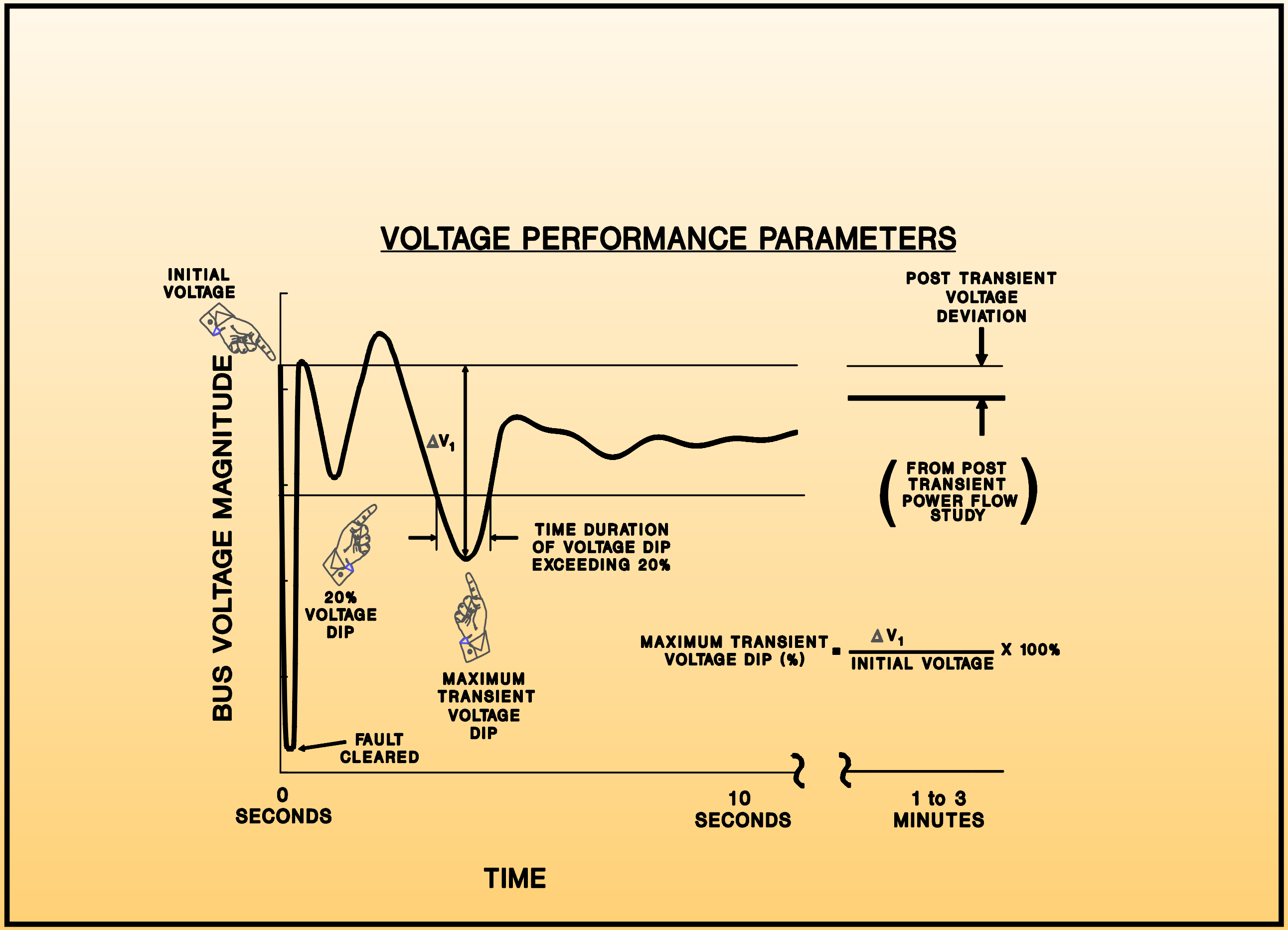
OVERVIEW

- DYNAMIC STABILITY STUDY RESULTS
- PROBLEMS DISCOVERED AND MITIGATION MEASURES
- DYNAMIC REACTIVE SUPPORT
- SENSITIVITY STUDIES, IMPACT OF DIFFERENT FACTORS
- CONCEPTUAL ARIZONA-SOUTHERN CALIFORNIA TRANSFER NOMOGRAM

WECC TRANSIENT STABILITY STANDARDS

VOLTAGE PERFORMANCE PARAMETERS



DYNAMIC STABILITY STUDIES

- **TO IDENTIFY CRITERIA VIOLATIONS AND ADDITIONAL DYNAMIC REACTIVE SUPPORT**
- **BASE CASES**
  - PEAK CASE
  - OFF-PEAK with 8075 MW EOR flow
  - OFF-PEAK with 8750 MW EOR flow (James Hsu option)
- **OUTAGES WITH 3-PHASE FAULTS**
  - PEAK CASE – ALL 500 KV SINGLE AND SELECTED DOUBLE OUTAGES
  - OFF-PEAK CASES - SINGLE OUTAGES
  - PALO VERDE-DEVERS AND HASSYAMPA-NORTH GILA
- **GE COMPUTER PROGRAM FOR DYNAMIC STABILITY ANALYSIS AND A PROGRAM TO IDENTIFY CRITERIA VIOLATIONS AND BUSES WITH HIGHEST VOLTAGE DIPS AND LOWEST FREQUENCIES WAS USED**

STUDY RESULTS. PEAK CASE

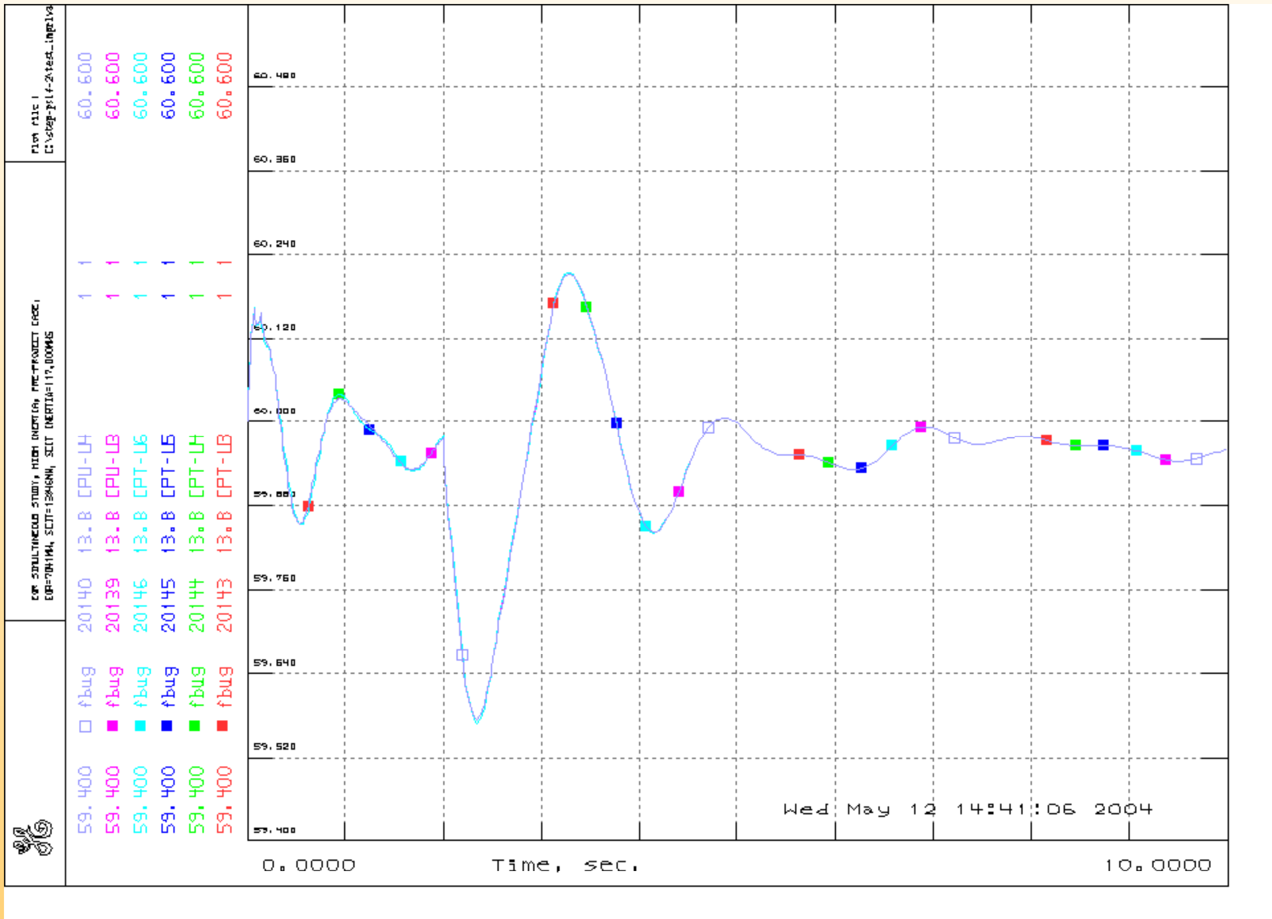
No violations, except for the Imperial Valley-Miguel outage with cross-tripping of La Rosita-Imperial Valley 230 kV line

Frequency violations in Cerro Prieto area of CFE

LOWEST FREQUENCY

AREA	BUS NAME	BUS KV	TYPE	MaxDip	@time
20	CPU-161	161	fbul	59.592	2.342
20	CPT-161	161	fbus	59.59	2.342
20	CPT-U3	13.8	fbug	59.568	2.342

PEAK CASE. IMPERIAL VALLEY-MIGUEL 500 KV OUTAGE



STUDY RESULTS. OFF-PEAK CASE

- Palo Verde- Devers outage

HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE		Initial	MaxDip	Prct	@time
26	WLMNTNLD	138	vbul		1.033	0.794	23.2	0.7
26	HARB	138	vbus		1.034	0.794	23.2	0.7
26	ADELSVC	500	vbug		1.05	0.815	22.5	0.663

Local Frequency Violations. Frequency lower than 59.6 HZ for more than 6 cycles

AREA	BUS NAME	BUS KV	TYPE	Cycles	From	To
21	DELRANCH	14.4	fbug	13.5	1.563	1.788
21	JJELMORE	14.4	fbug	13.5	1.563	1.788
21	LEATHERS	14.4	fbug	13.5	1.563	1.788

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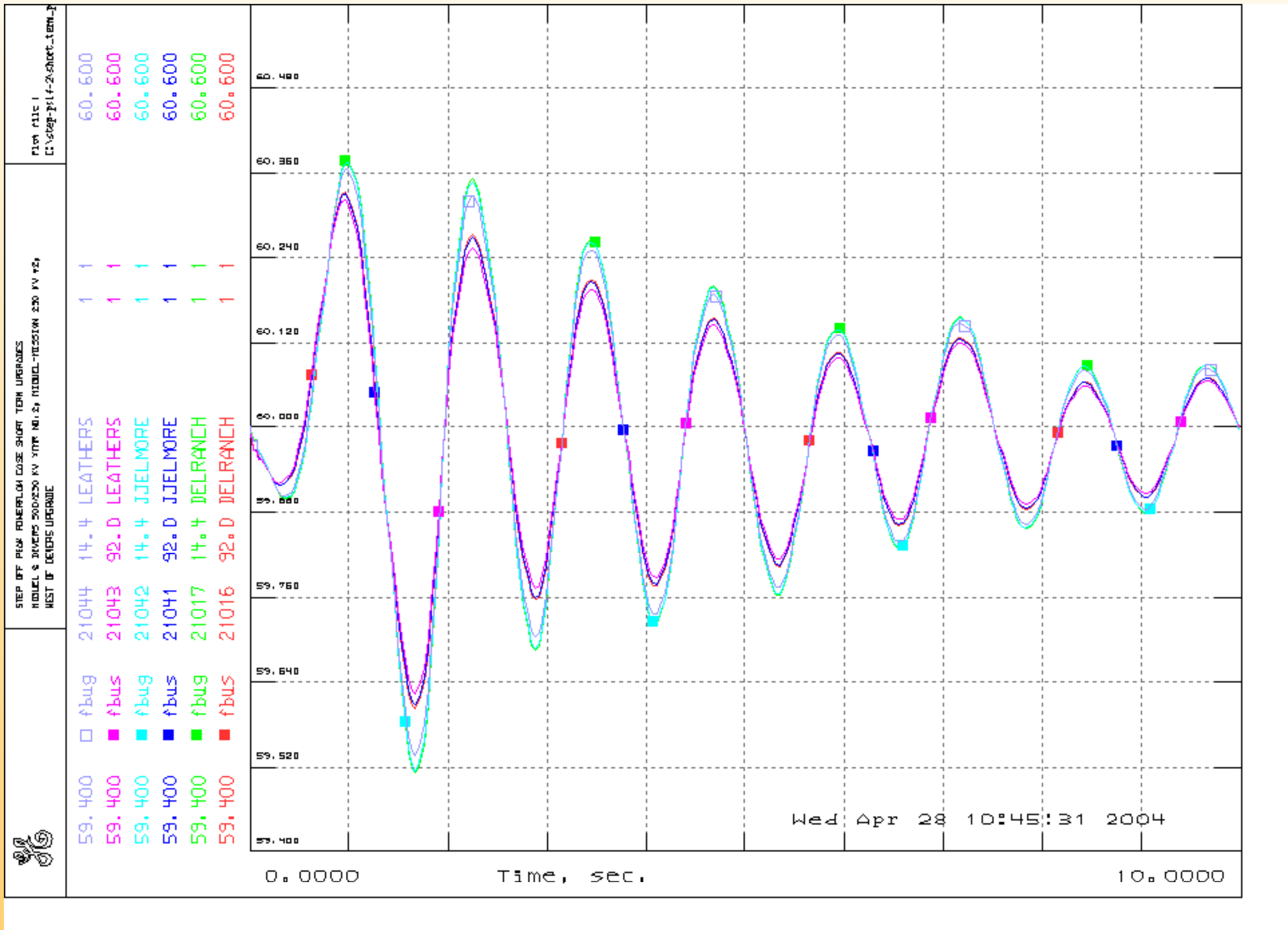
PALO VERDE-DEVERS OUTAGE frequency



HASSAYAMPA-NORTH GILA OUTAGE

Voltage violations on 31 load buses

Highest Voltage dip:

AREA	BUS NAME	BUS KV	TYPE	Initial	MaxDip	Prct	@time
24	VALLEY-S	115	vbul	1.004	0.748	25.4	0.738
24	VALLEYSC	500	vbus	1.04	0.784	24.6	0.738
24	DEVERS	500	vbug	1.025	0.751	26.8	0.7

Lowest frequency:

AREA	BUS NAME	BUS KV	TYPE	MaxDip	@time
54	AURORA 8	69	fbul	59.672	3.737
54	SYNC_D08	69	fbus	59.675	3.737
54	SYNC_G19	13.2	fbug	59.655	3.775

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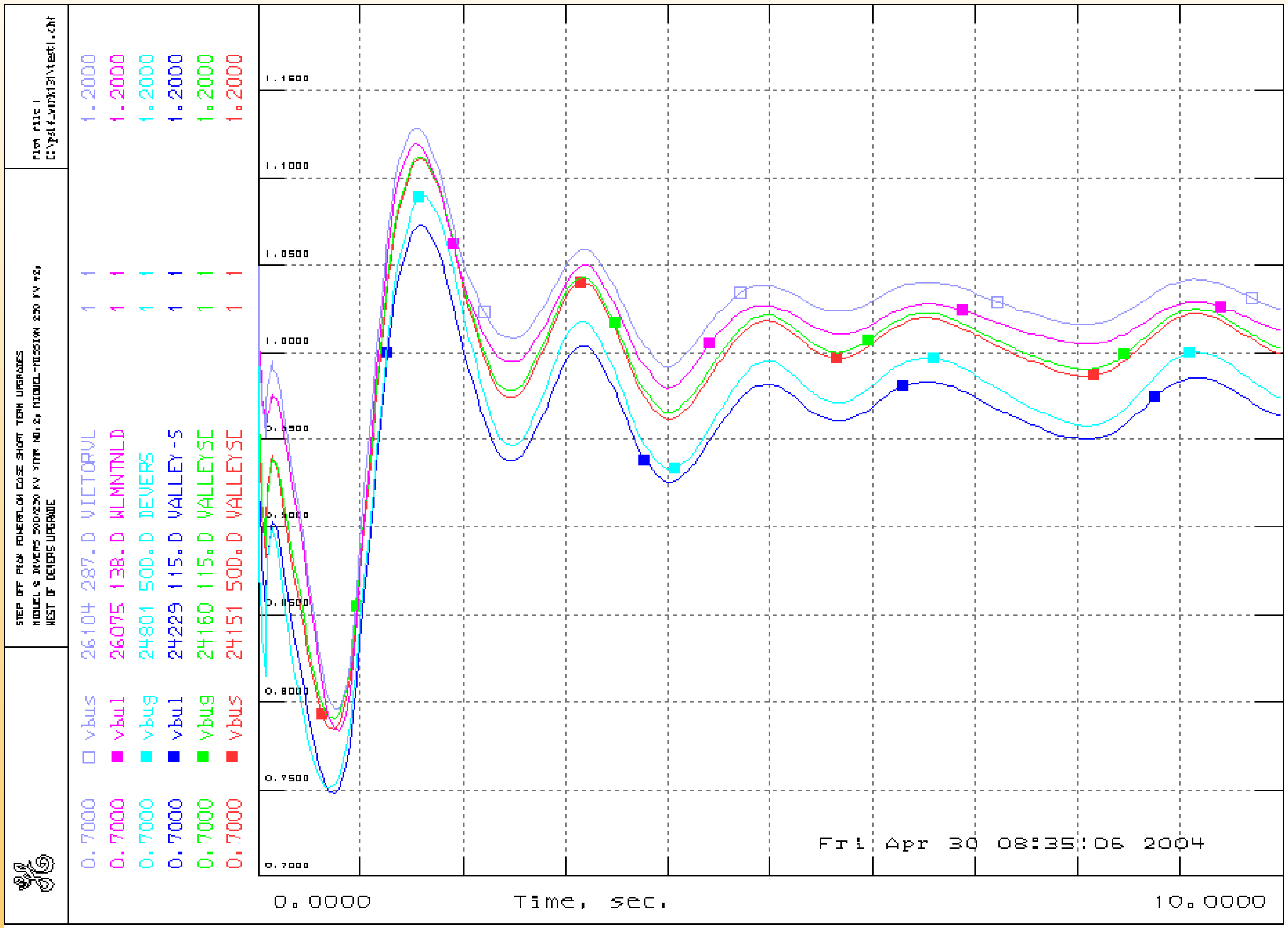
HASSAYAMPA-NORTH GILA OUTAGE voltage



VOLTAGE VIOLATIONS MITIGATION

HASSAYAMPA-NORTH GILA OUTAGE

200 MVAR STATCOM at Devers 500 kV

No violations. Voltage dip reduced by 4.5%

HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE		Initial	MaxDip	Prct	@time
24	VALLEY-S	115	vbul		1.004	0.79	21.3	0.7
26	VICTORVL	287	vbus		1.049	0.831	20.8	0.738
24	DEVERS	500	vbug		1.025	0.797	22.3	0.625

LOWEST FREQUENCY

AREA	BUS NAME	BUS KV	TYPE	MaxDip	@time
20	PAR-230	230	fbul	59.695	1.863
20	CPD-230	230	fbus	59.693	1.863
20	CPD-U1	13.8	fbug	59.676	1.863

Minimum STATCOM size

140 MVAR – one violation

160 MVAR - no violations

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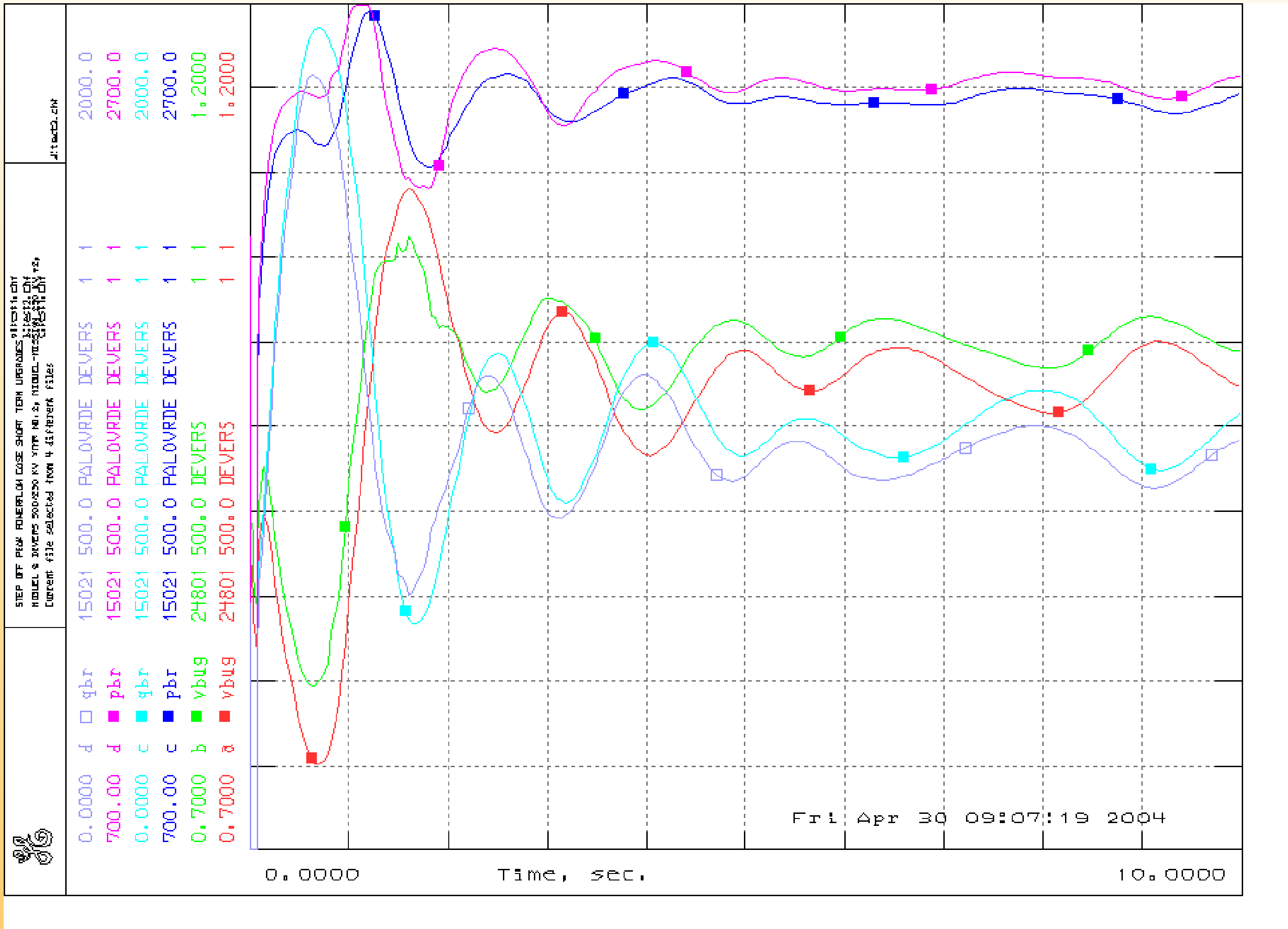
WITH AND WITHOUT 200 MVAR STATCOM



VOLTAGE VIOLATIONS MITIGATION

HASSAYAMPA-NORTH GILA OUTAGE

200 MVAR SVC — No violations

HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE		Initial	MaxDip	Prct	@time
24	VALLEY-S	115	vbul		1.004	0.78	22.3	0.7
24	VALLEYSC	500	vbus		1.04	0.816	21.6	0.7
24	DEVERS	500	vbug		1.025	0.786	23.4	0.663

LOWEST FREQUENCY

AREA	BUS NAME	BUS KV	TYPE		MaxDip	@time
20	PAR-230	230	fbul		59.694	1.863
20	CPD-230	230	fbus		59.692	1.863
20	CPD-U1	13.8	fbug		59.675	1.863

Minimum SVC size

180 MVAR – one violation, equivalent to 140 MVAR STATCOM

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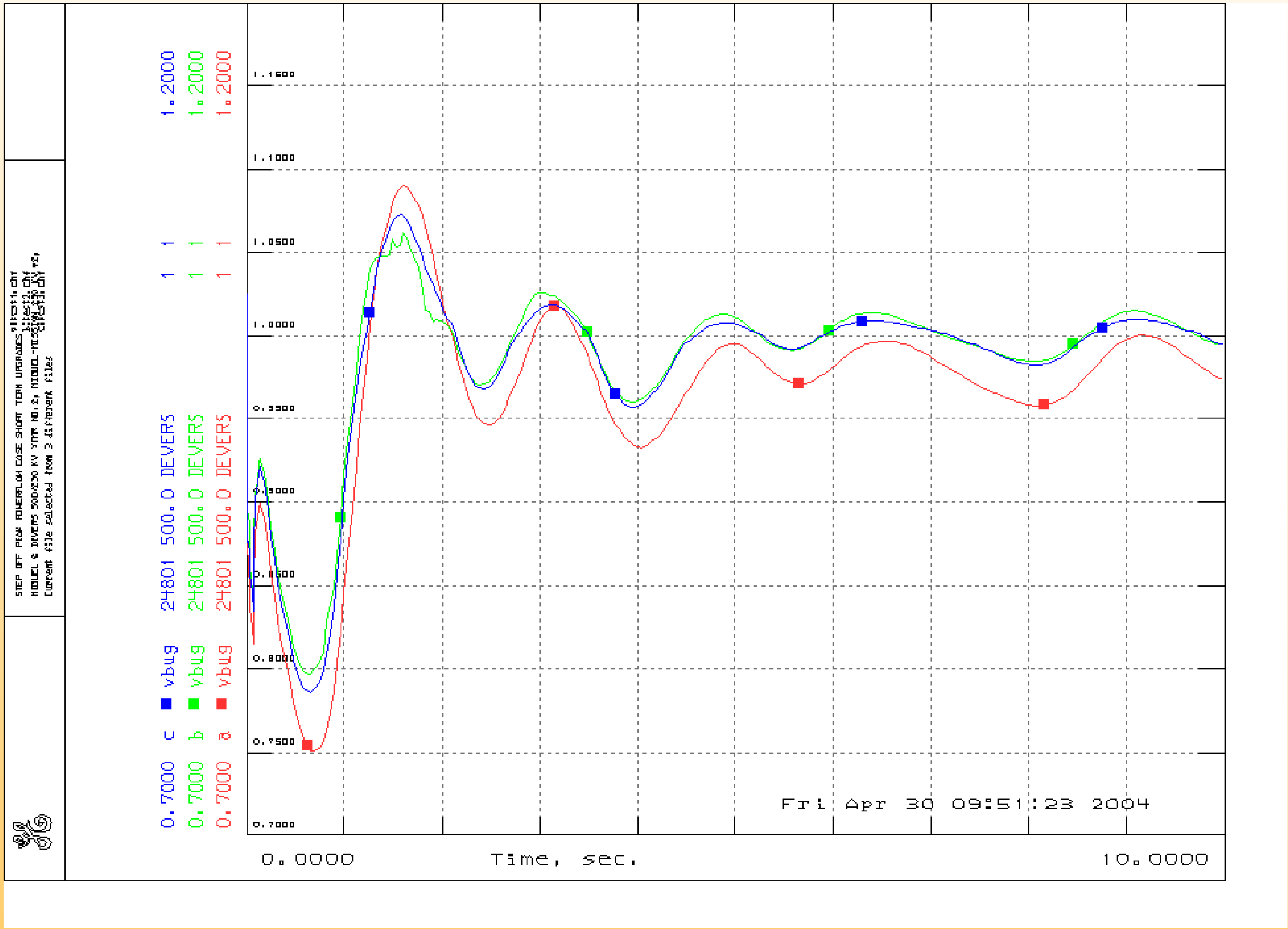
NO REACTIVE SUPPORT, 200 MVAR STATCOM AND 200 MVAR SVC



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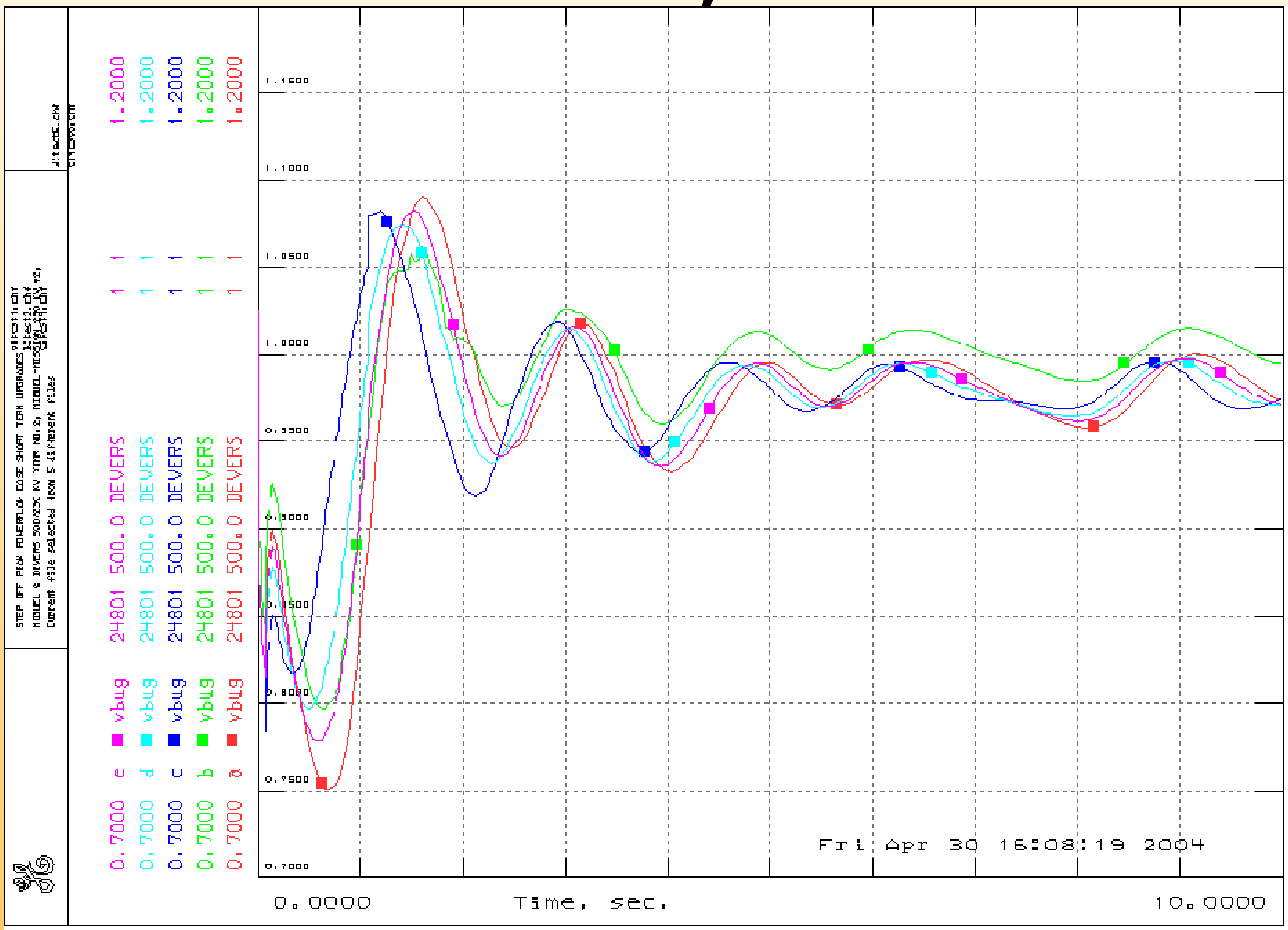
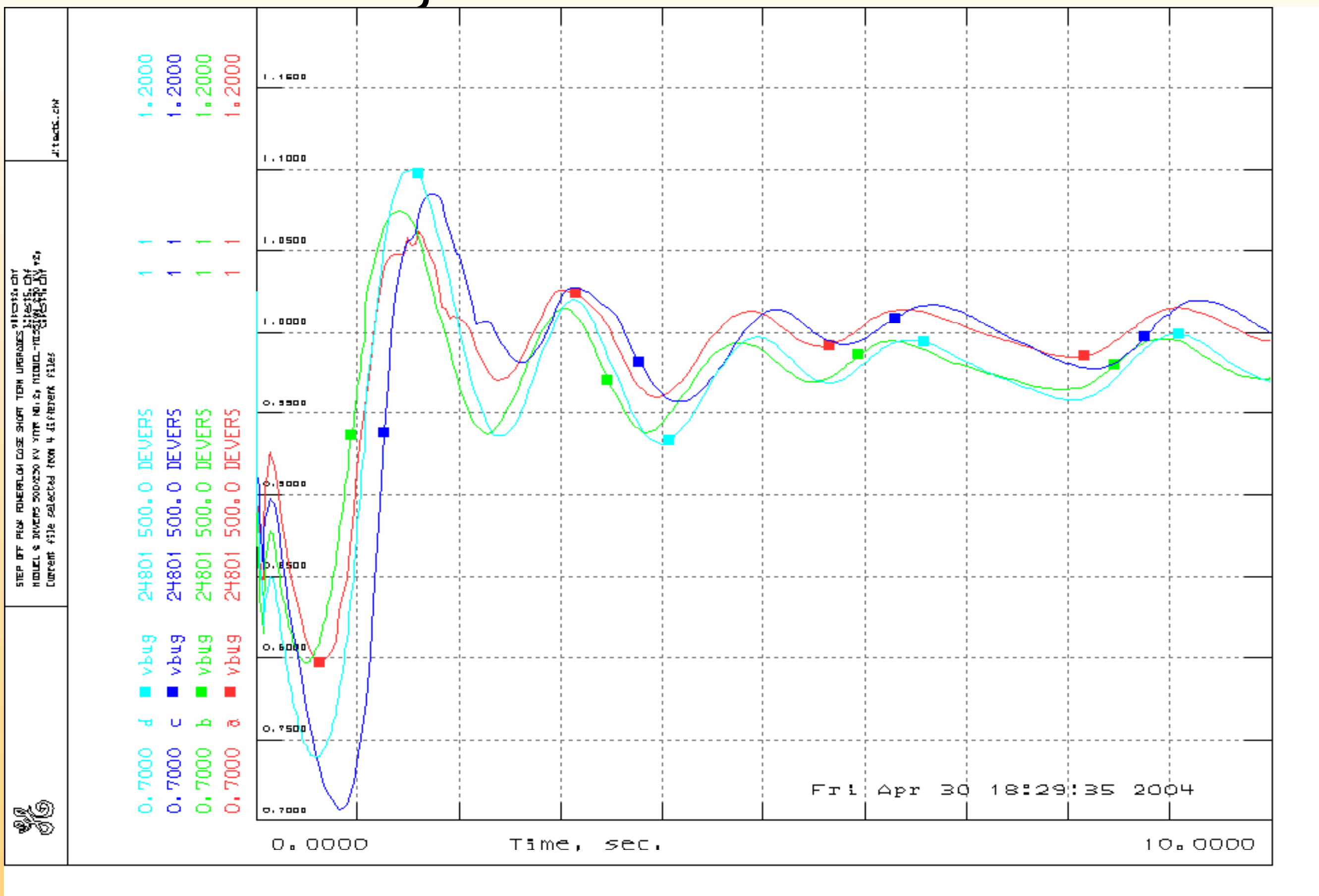
NO COMPENSATION (a), 200 MVAR STATCOM (b) TCSC-10 (e), 20 (d), 40 (c) OHM)



SENSITIVITY 1. MORE INDUCTION MOTORS (50% in the desert areas)

- Multiple voltage violations both with 200 MVAR STATCOM and 20 ohm TCSC
- TSC more effective : 33.3% voltage dip with STATCOM and 27.9% with TCSC

COMPARISON: 20% AND 50% INDUCTION MOTORS, STATCOM OR TCSC



a- STATCOM and 20% ind.motor

b- TCSC and 20% ind. Motor

c- STATCOM and 50% ind. motor

d- TCSC and 50% ind. motor

SENSITIVITY 2. NO MOUNTAIN VIEW (1000 MW)

- Mountain View generation replaced by Alamitos, Huntington Beach, Redondo Beach
- Southern California inertia slightly higher without Mountain View
- Voltage violations both with 200 MVAR STATCOM and 20 ohm TCSC
- TSC showed better performance than STATCOM (voltage dip 26.3% with STATCOM, 25.2% with TSC)

SENSITIVITY 3. INERTIA AT HASSYAMPA/ GILA

Total generation at Hassyampa and Gila, EOR and other flows approximately the same

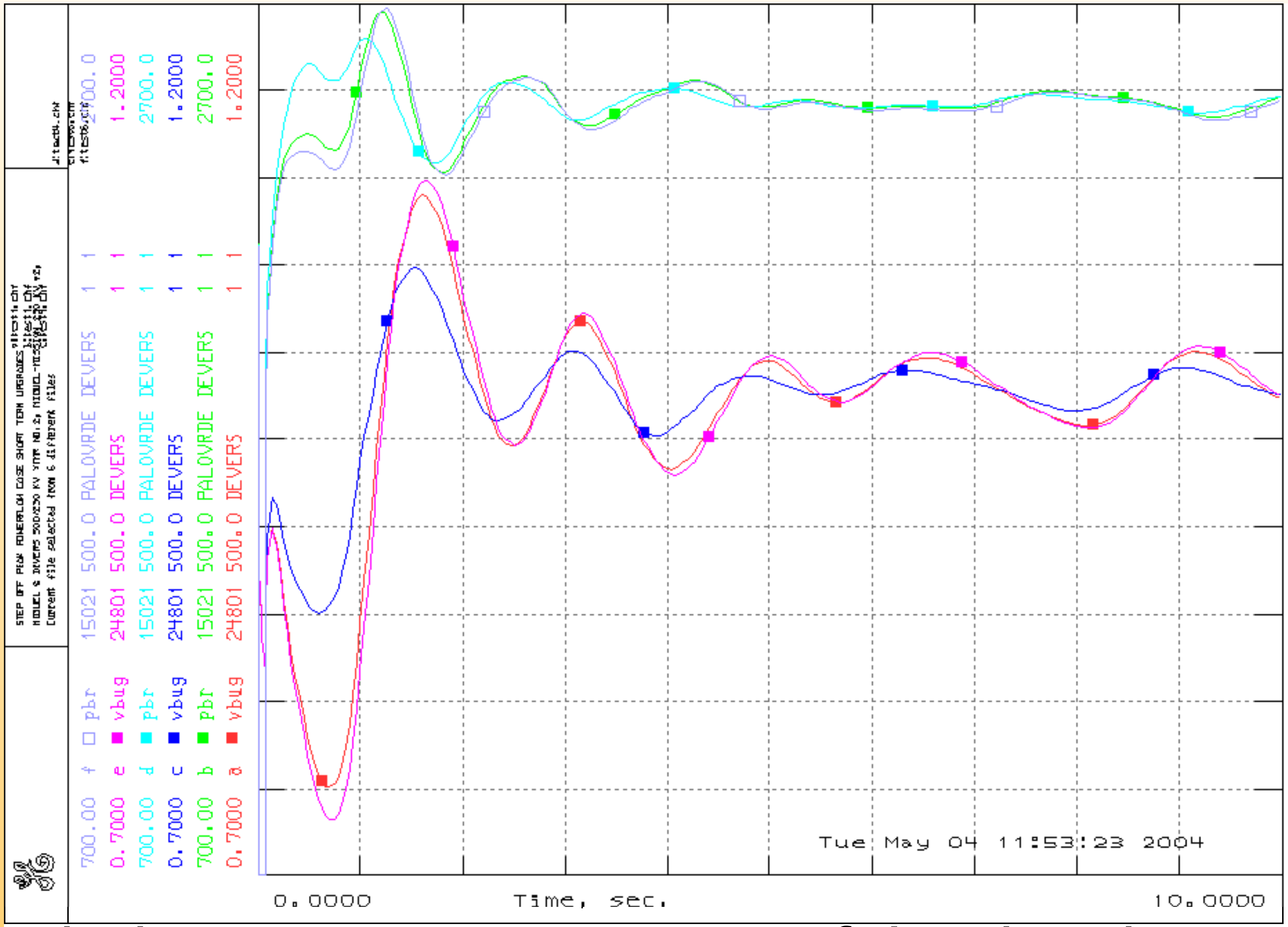
- Higher inertia : 33 units, 42861 MWsec versus 20 units and 26437 MWsec in the base case
- No reactive support required

HIGHEST VOLTAGE DIP

AREA	BUS NAME	BUS KV	TYPE		Initial	MaxDip	Prct	@time
24	VALLEY-S	115	vbul		1.004	0.849	15.4	0.625
24	VALLEYSC	500	vbus		1.04	0.884	15	0.625
24	DEVERS	500	vbug		1.025	0.851	17	0.588

- Lower inertia - 18 units, 24274 MWsec versus 20 units and 26437 MWsec in the base case
- EOR flow lower (8056 MW versus 8075 MW in the base case)
- More voltage violations

BASE CASE AND CASES WITH HIGH AND LOW INERTIA



a,b- base case

e,f- low inertia

c,d- high inertia

SENSITIVITY 4. WHERE TO INSTALL TCSC

ON PALO VERDE – DEVERS 500 KV LINE

- 60 miles from Devers
- 60 miles from Palo Verde
- At Devers substation

- Almost no difference in the results

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STUDIES OF FACTORS WHICH MAY IMPACT DYNAMIC STABILITY PERFORMANCE

- INERTIA IN ARIZONA AND SOUTHERN CALIFORNIA
- SOUTHERH CALIFORNIA GENERATION AND LOAD
- BULK POWER TRANSFERS
- a. Palo Verde to Southern California (Palo Verde West)
- b. Las Vegas to Southern California transfers (Northern WOR)
- c. Northern California to Southern California transfers (Path 26)
- d. Pacific DC Intertie to Southern California transfers (Path 65)
- Arizona to Nevada transfers (Northern EOR)
- Other transfers

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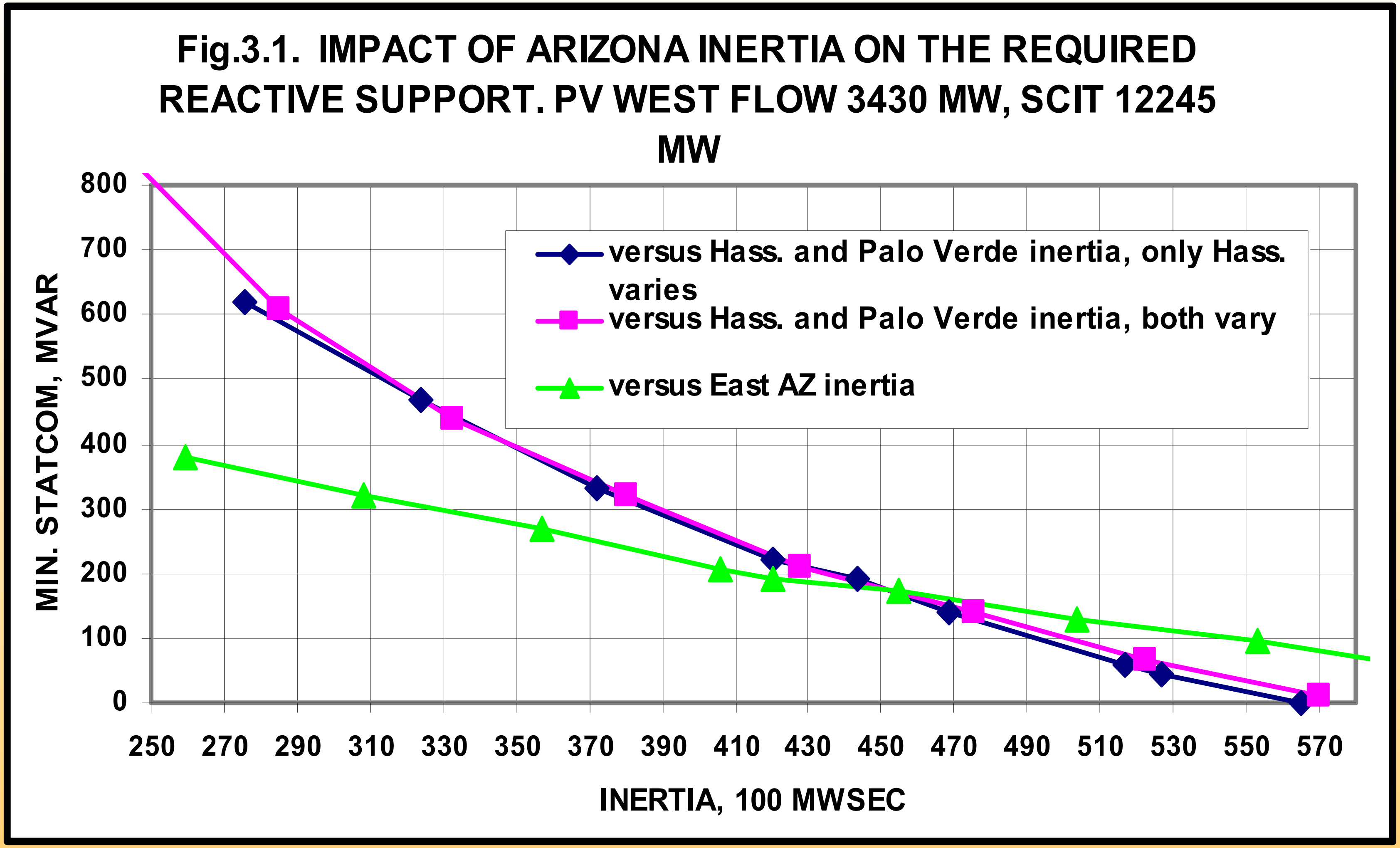
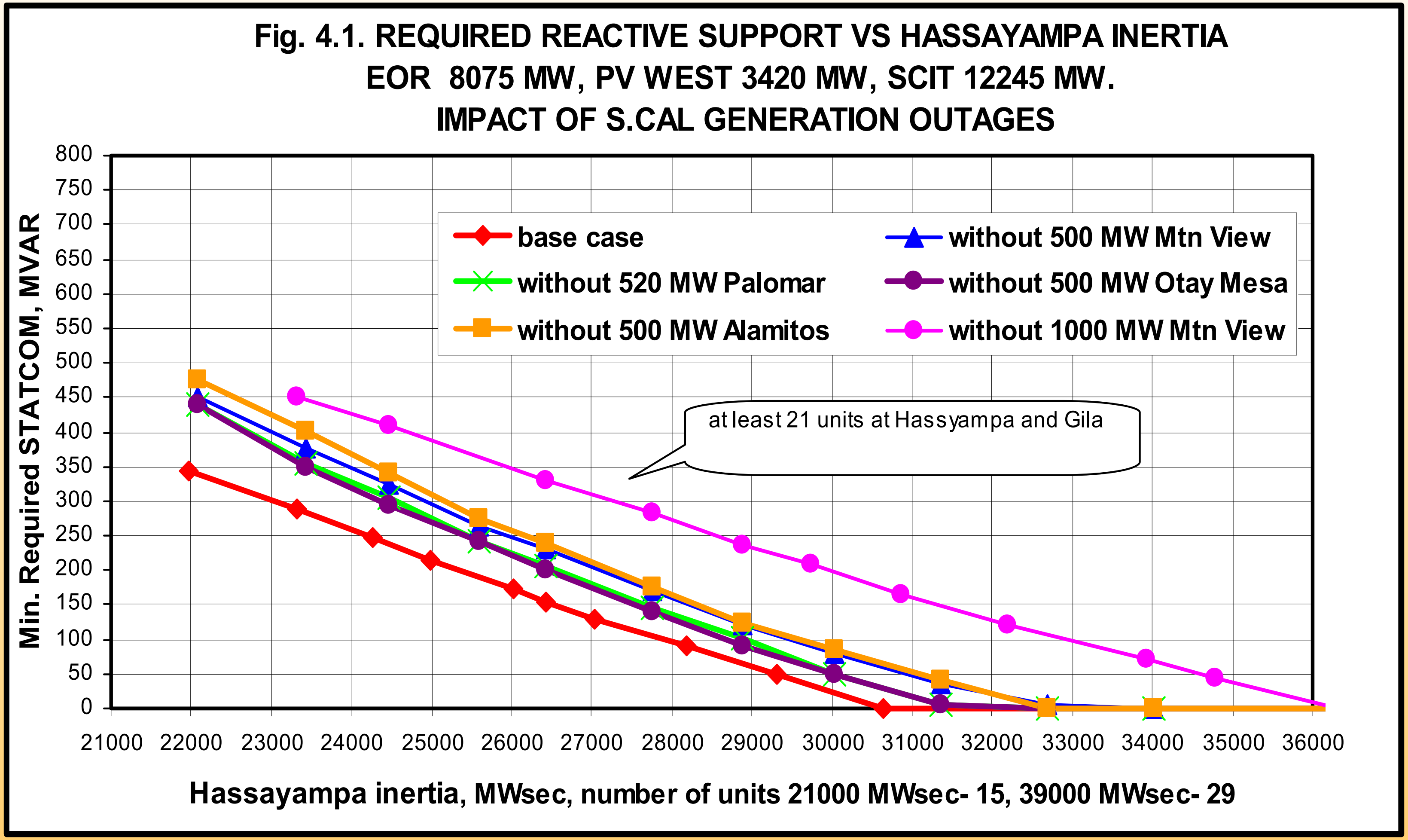
INERTIA SENSITIVITIES



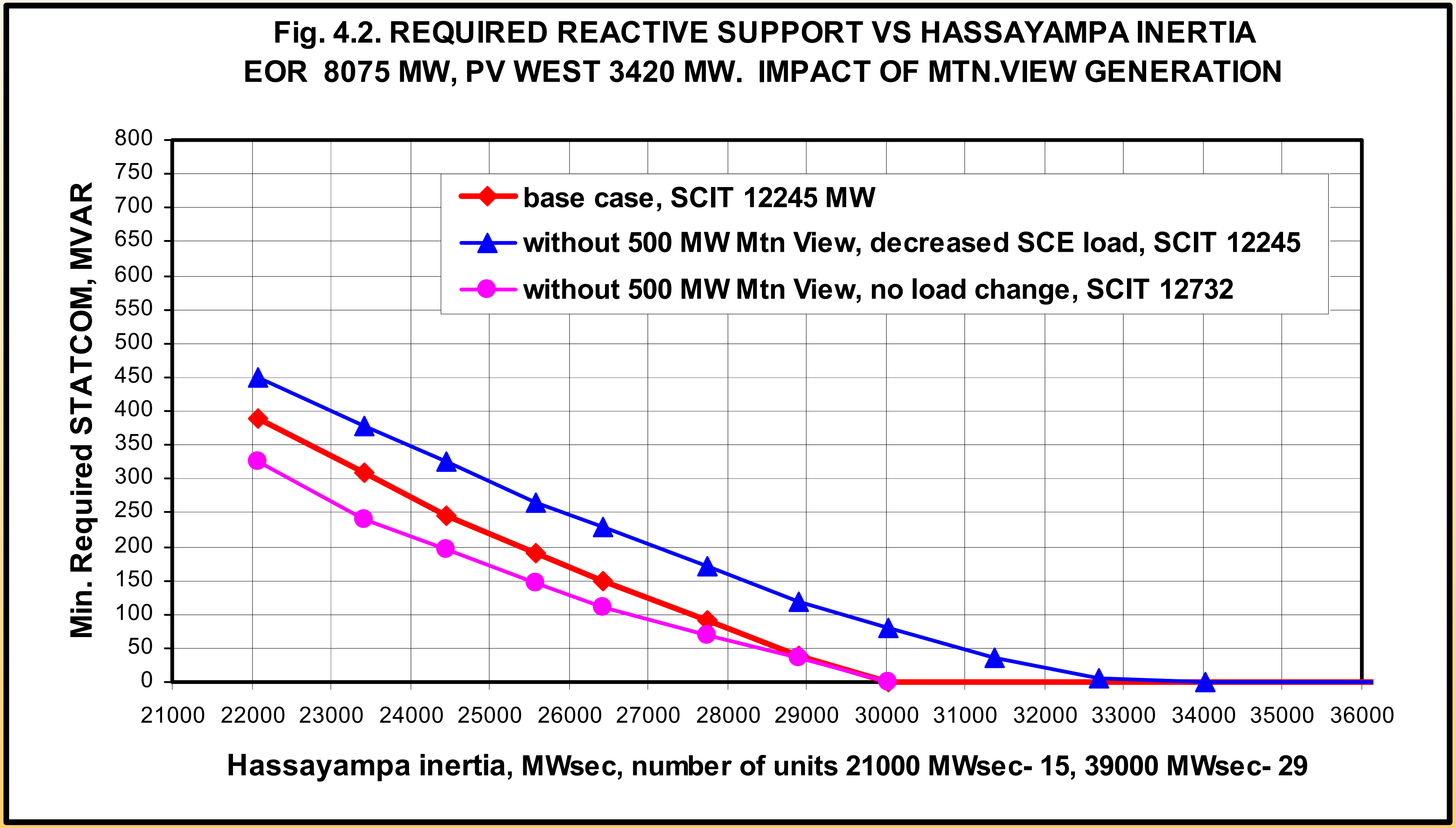
INERTIA IMPACT

- At Hassayampa, Gila River and Palo Verde - significant impact. The higher the inertia, the lower the required reactive support.
- The rest of Arizona - approximately half of the impact of the Palo Verde, Hassayampa and Gila River generation inertia.
- Southern California inertia - no impact

SOUTHERN CALIFORNIA GENERATION SENSITIVITIES



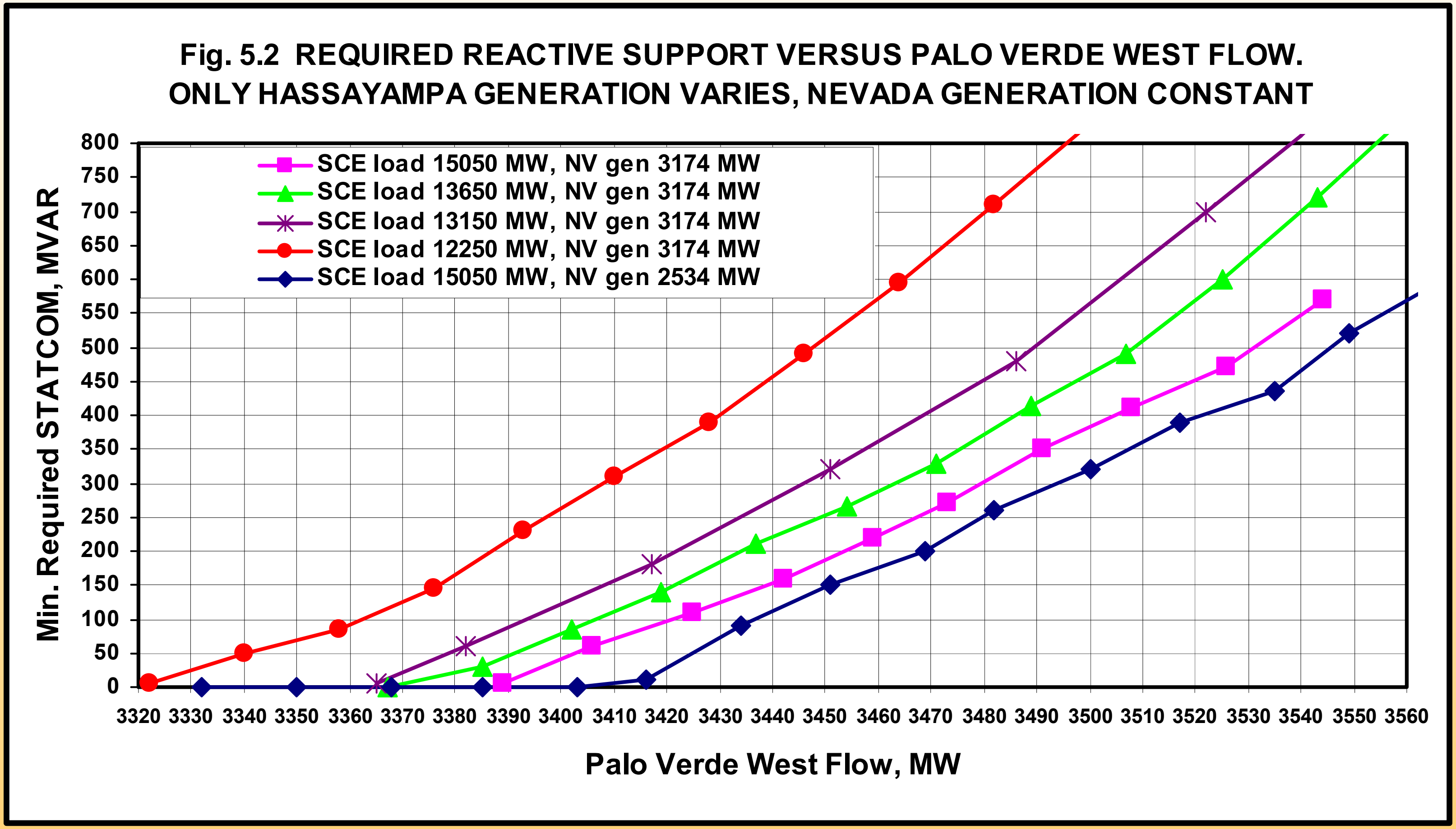
GENERATION IMPACT DEPENDS ON MODELING



SOUTHERN CALIFORNIA GENERATION IMPACT

Southern California generation impacts the reactive support requirement. However, the results depend on how the sensitivity case is modeled and on flows on the major paths to Southern California.

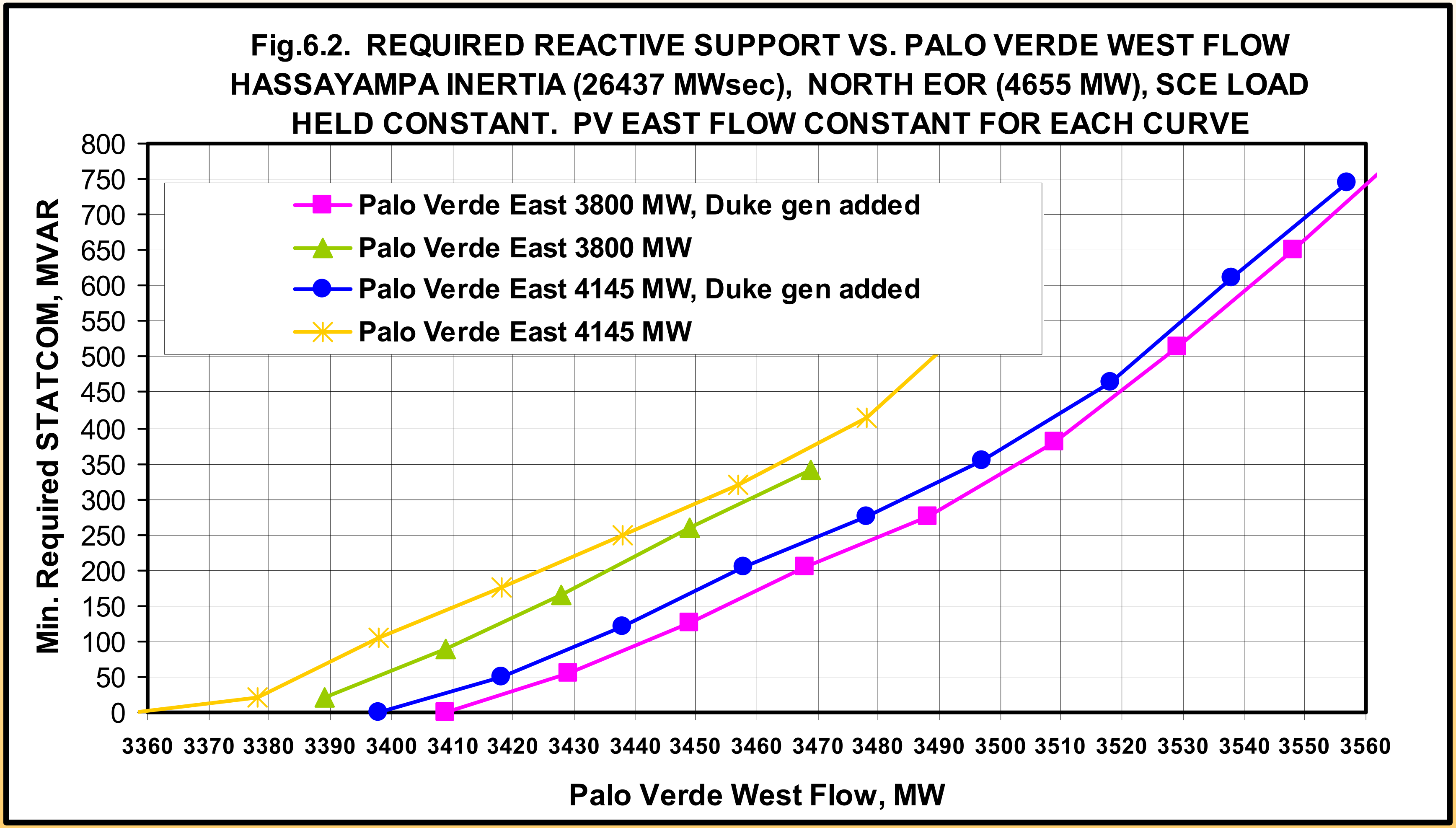
SOUTHERN CALIFORNIA LOAD SENSITIVITIES



SOUTHERN CALIFORNIA LOAD IMPACT

- **Lower Southern California load results in higher reactive power support requirements if the flows between Southern California and Arizona held constant.**
- **The amount of required reactive support depends significantly on how the change in load is compensated, thus on the flow on the major paths.**
- **For changes in the amount of local load at Valley and Devers, the impact was no different than for an equivalent change across Southern California's entire load.**

TRANSFER SENSITIVITIES. PALO VERDE WEST AND PALO VERDE EAST



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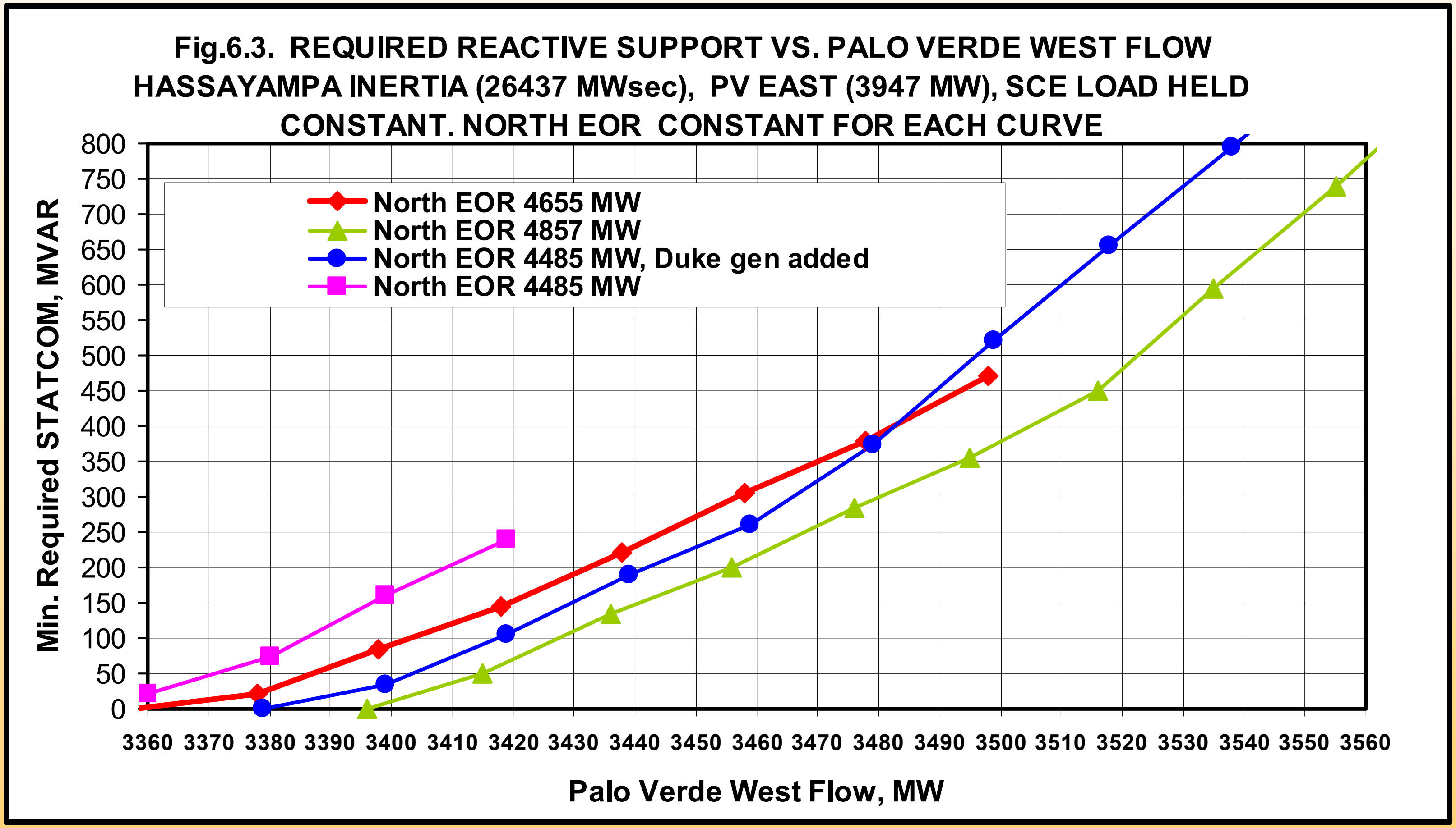
TRANSFER SENSITIVITIES. PALO VERDE WEST AND NORTH EOR



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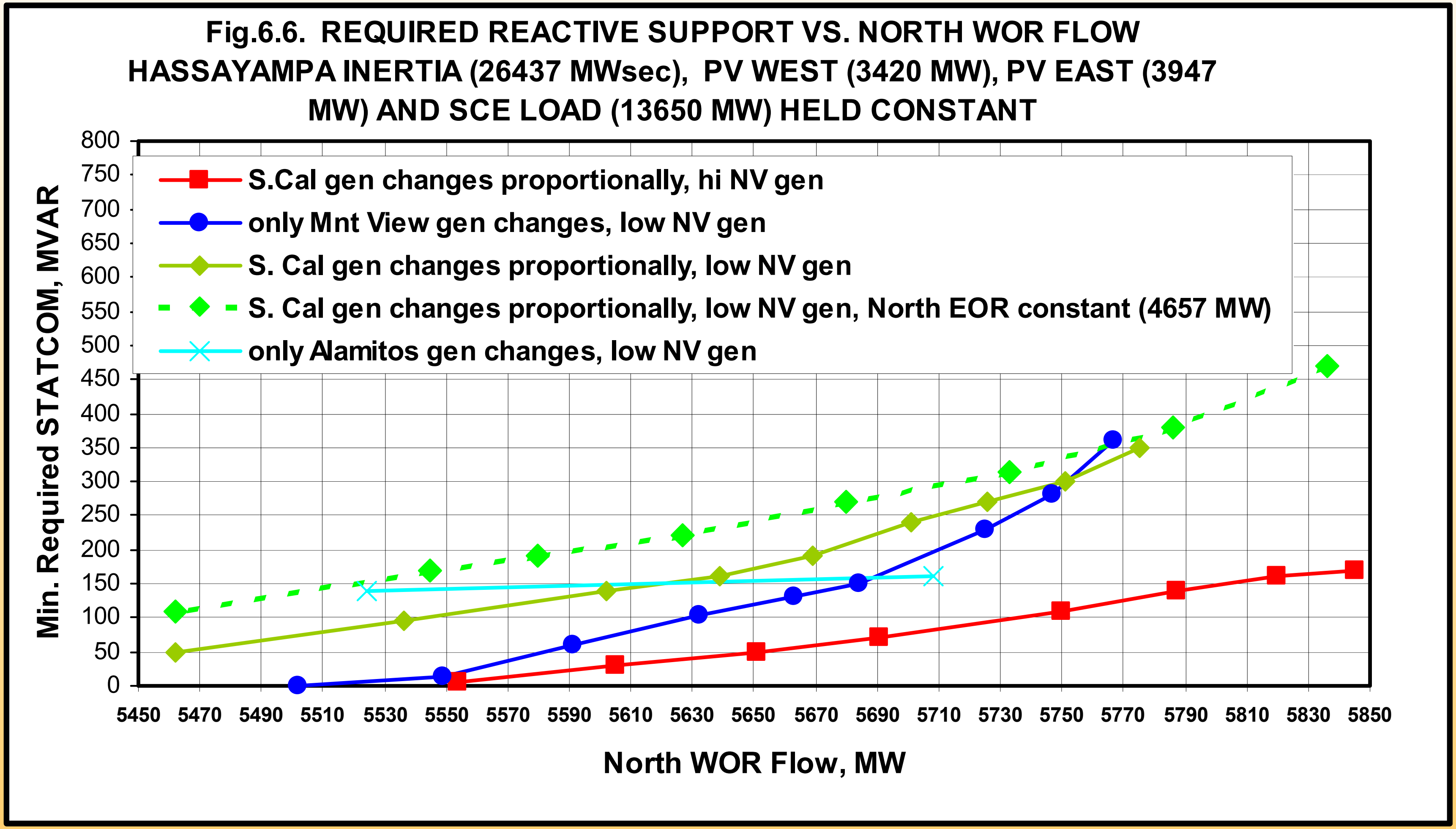
TRANSFER SENSITIVITIES. NORTHERN WOR



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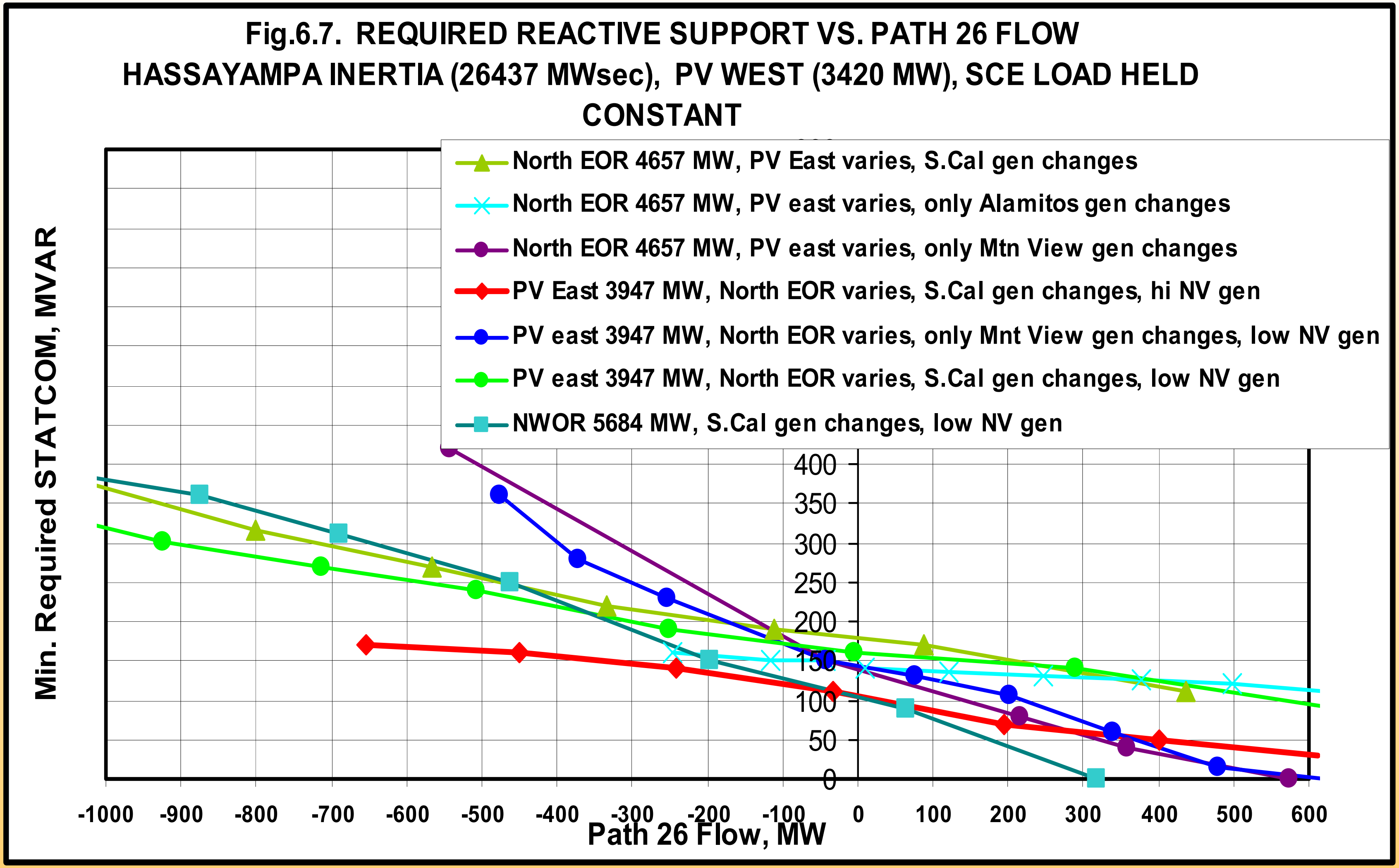
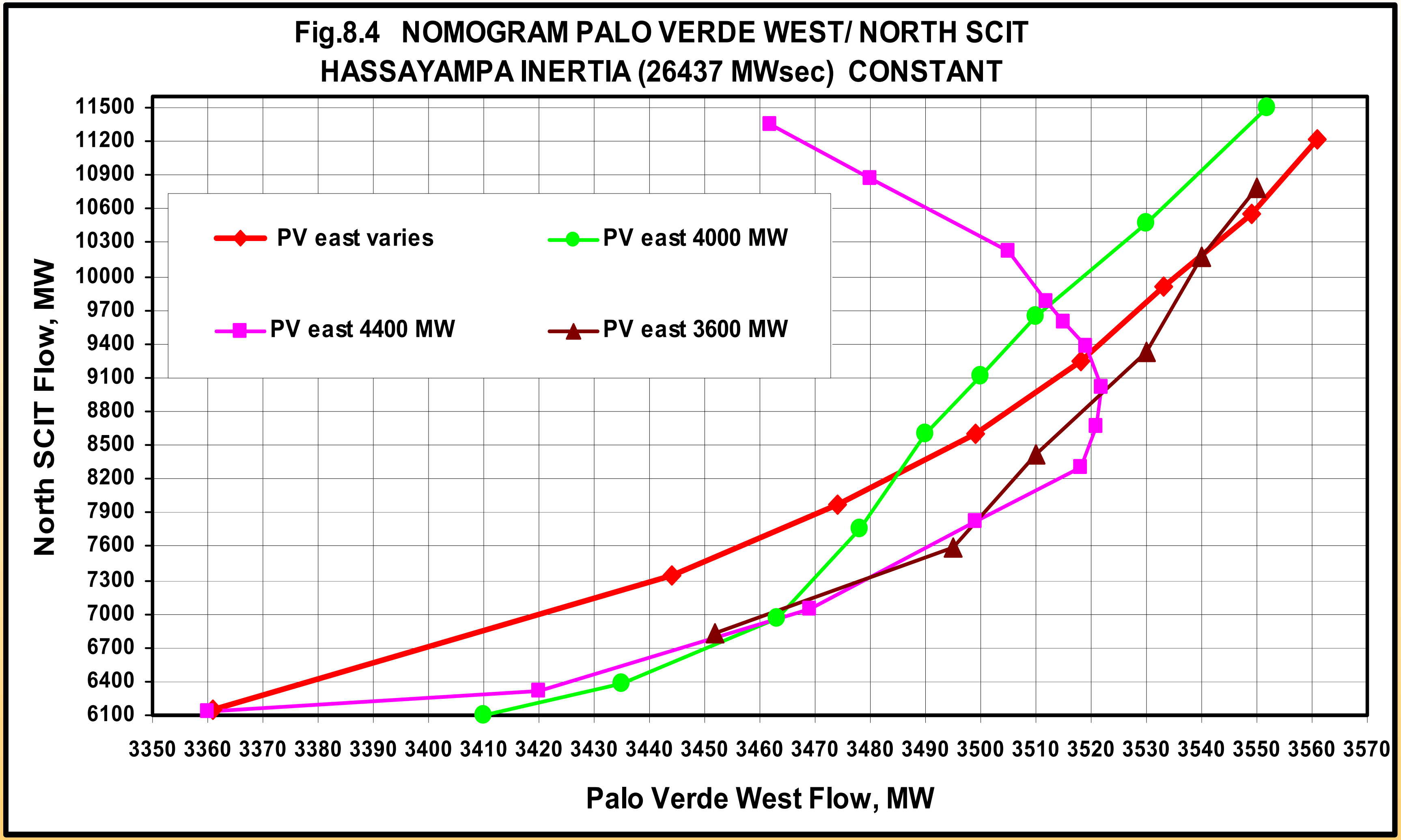
TRANSFER SENSITIVITIES. PATH 26



IMPACT OF MAJOR PATH FLOWS

- **Palo Verde West highest impact**
- **Palo Verde East some impact, depends on which other flows are held constant.**
- **Impacts of the North WOR, North EOR and Path 26 flows depend on the modeling assumptions, should not be considered alone.**
- **Factors for the new Arizona-Southern California transfer nomogram: flow on the Palo Verde West lines, combined flow to the Southern California from the North (North SCIT) and the Palo Verde East flow.**

CONCEPTUAL NOMOGRAM



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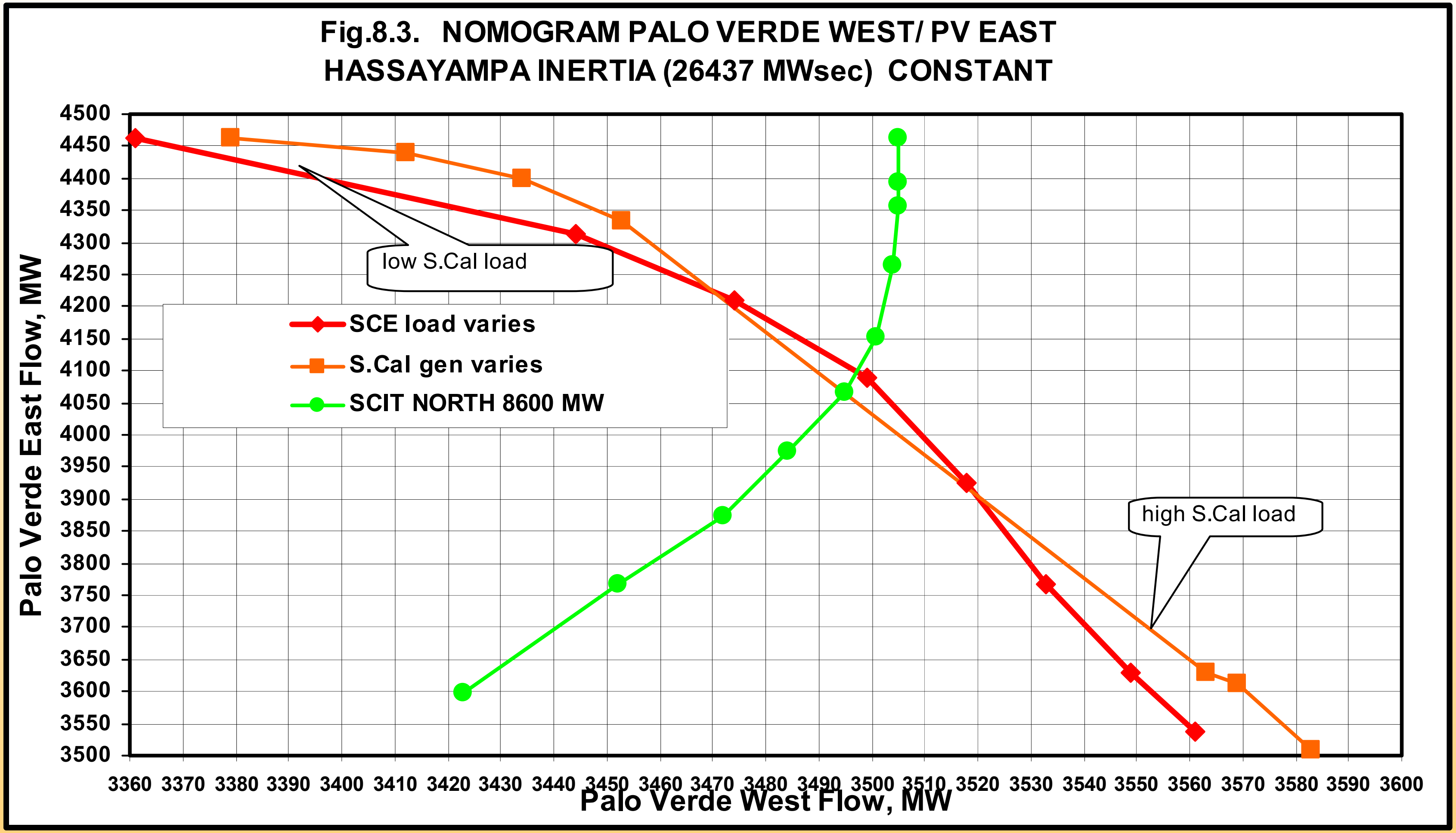

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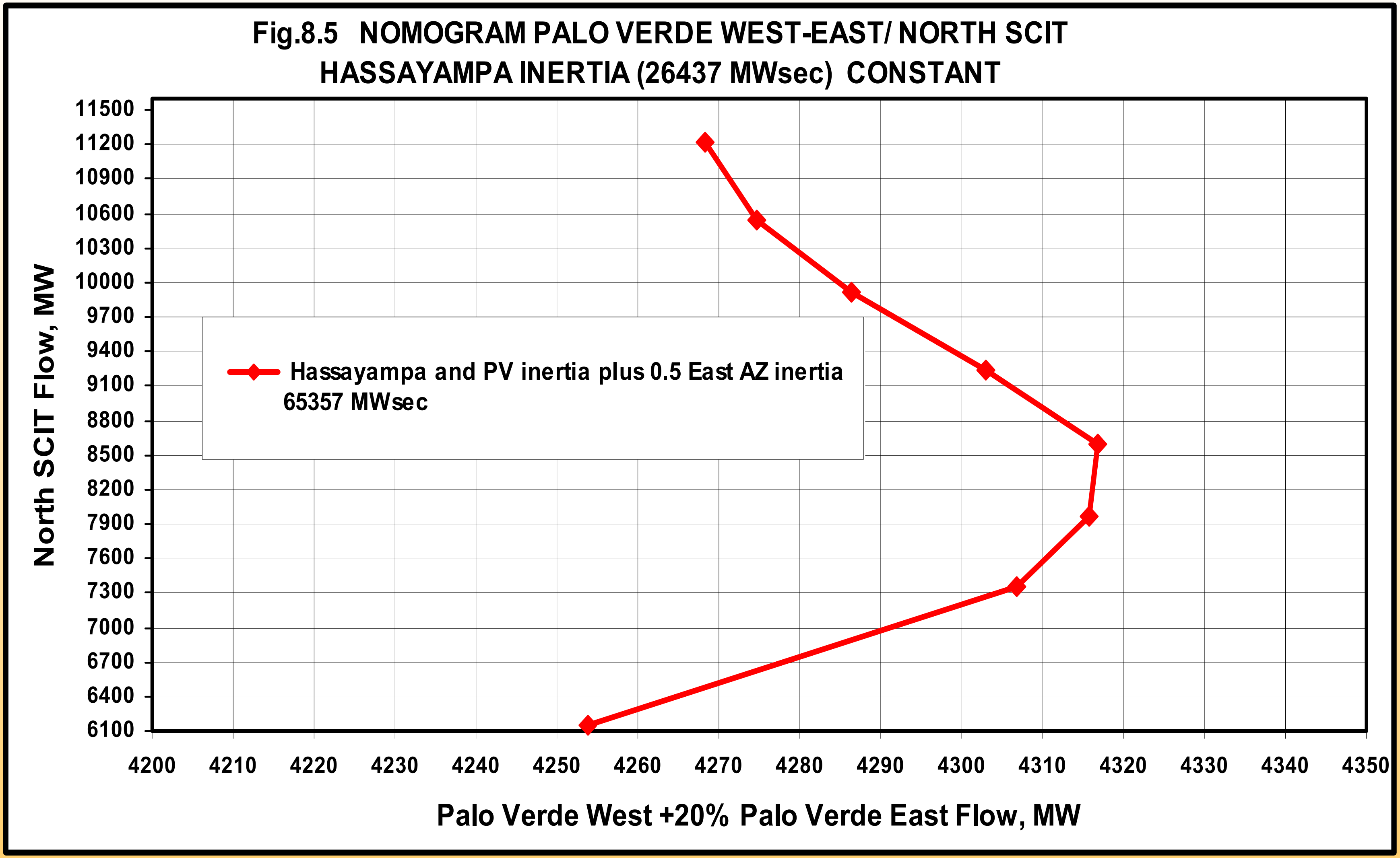
CONCEPTUAL NOMOGRAM



CONCEPTUAL NOMOGRAM