



**CALIFORNIA ISO**

California Independent  
System Operator

# **STEP Economic Screening Study**

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*California ISO Grid Planning*

*July 29, 2003*



## Purpose

- What is a market simulation tool?
- What are the study input assumptions?
- How to assess the transmission benefits?
- Presenting initial results.
- Soliciting input and feedback.



## Market Simulation Tool

### Market simulation

Predicting economic and physical performance of large power networks using a transmission constrained economic dispatch.

### Transmission constrained economic dispatch

Creating an economic generation dispatch which minimizes total production cost subject to generation, transmission and operational constraints.



## Market Simulation Tool

### Generation

- capacity
- costs (fuel, O&M)
- outages
- min. up/down times

### Transmission

- network data
- constraints
- outages
- operation rules

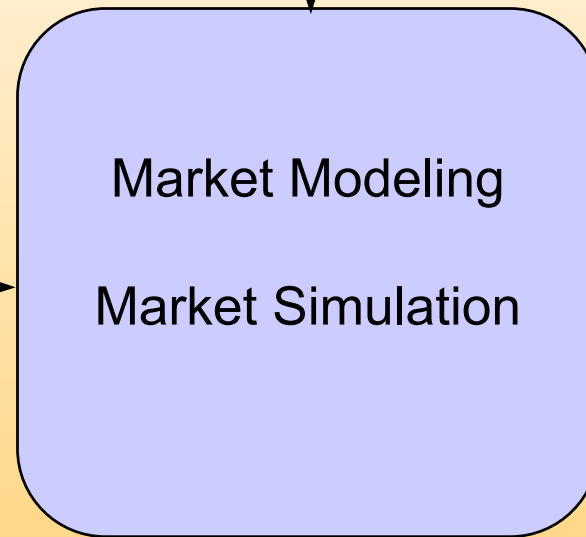
### Load

- distribution
- hourly variations
- load forecast

### Others

- hydro data

User specified scenarios  
(gas/hydro)



Additional Scenarios

### Unit Dispatch

- hourly dispatch
- capacity factors
- production cost

### Transmission

- hourly flows
- flow duration curves
- congested paths/lines
- shadow price

### Prices

- LMP for loads
- LMP for generators



## General Input Assumptions

- Study year 2008.
- Based on case developed by SSG-WI technical studies work group.
- Average hydro conditions.
- Average gas price \$3.

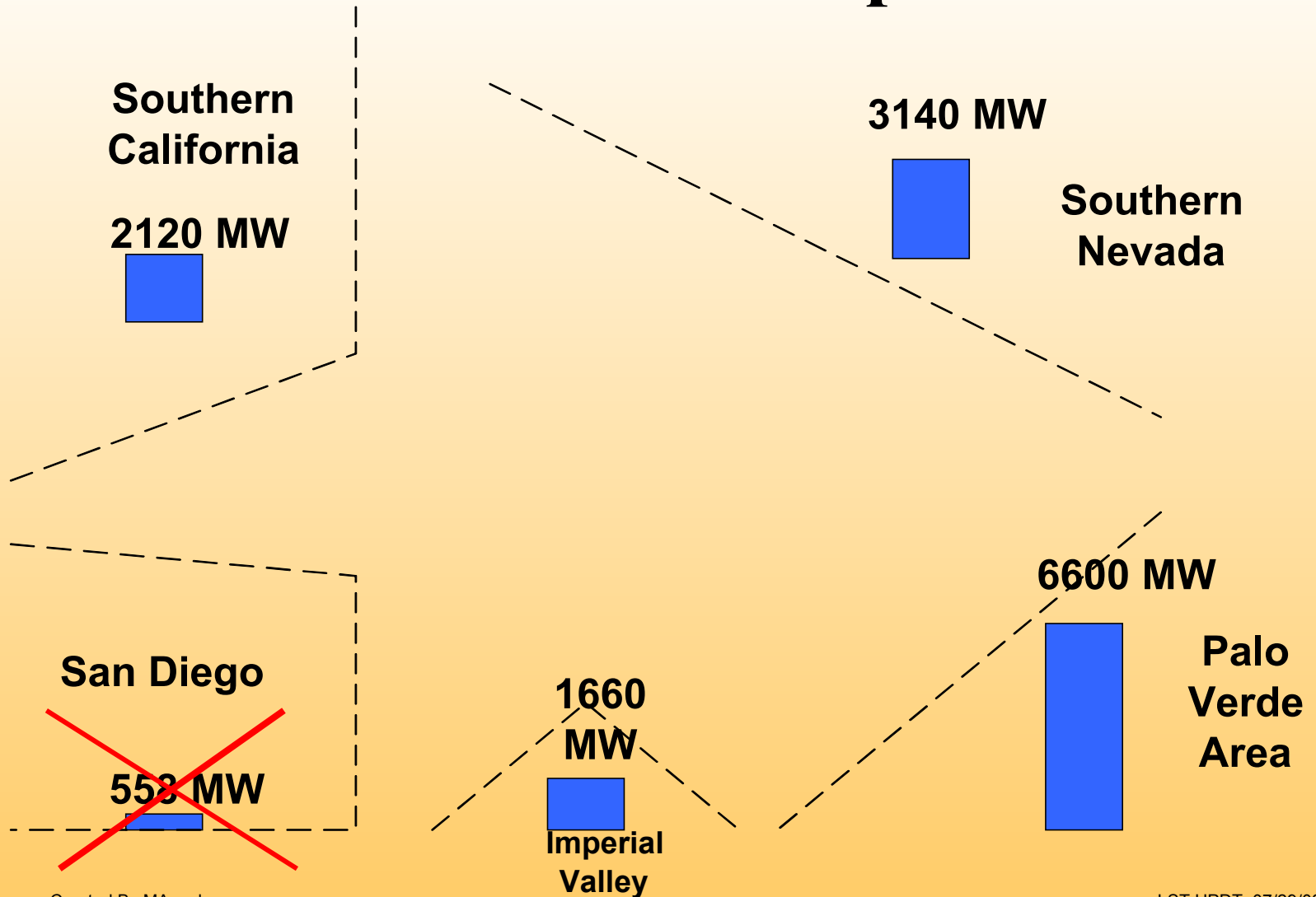


## Generation Assumptions

- New generation additions: plants under construction, online by 1/1/04, with an exception made in the case of plants permitted and well under construction.
- Plants retirements: Announced retirements including Mohave units were assumed off-line.



## Generation Assumptions





## Generation Assumptions Operational Cost

Fuel Type	Technology	Size	Vintage	Heat Rate	VOM \$/MWh
Gas/Oil	Steam	<100 MW	Pre 1960	12,500	\$5.00
Gas/Oil	Steam	>100 MW	Pre 1960	11,500	\$5.00
Gas/Oil	Steam	<100 MW	Post 1960	10,500	\$5.00
Gas/Oil	Steam	>100 MW	Post 1960	9,500	\$3.00
Gas	SCCT		Pre 1985	13,500	\$8.00
Gas	CCCT		Pre 1985	9,300	\$5.00
Gas	SCCT	<70 MW	Post 1985	9,500	\$5.00
Gas	SCCT	>70 MW	Post 1985	10,500	\$5.00
Gas	CCCT		Post 1985	7,250	\$2.00
Coal	Steam	<100 MW	Pre 1960	12,000	\$4.00
Coal	Steam	>100 MW	Pre 1960	11,000	\$2.00
Coal	Steam	<100 MW	Post 1960	11,000	\$3.00
Coal	Steam	>100 MW	Post 1960	10,500	\$2.00
Coal	Fluid Bed			10,500	\$2.00
Diesel				11,000	\$12.00
Gas/Oil	CCCT		Post 2001	7,000	\$2.00



## Generation Assumptions Maintenance Outage

<b>Technology Type</b>	<b>Maintenance Outage Rate</b>
Combined Cycle	7%
Combustion Turbine	7%
Coal Plant	10%
Steam Oil or Gas	10%
Nuclear	12%
Geothermal	12%



## Transmission Assumptions

- Transmission network: WECC 2008 base case. Same as used in the STEP technical analysis.
- Using the most recent path rating catalog for capacity numbers.
- Using nomograms to reflect system constraints.



## Load Assumptions

- Study year 2008.
- Unlike power flow analysis, market simulation tools require hourly load shapes.
- Load peaks, shapes and growth rates are obtained from WECC 2002 L&R report.

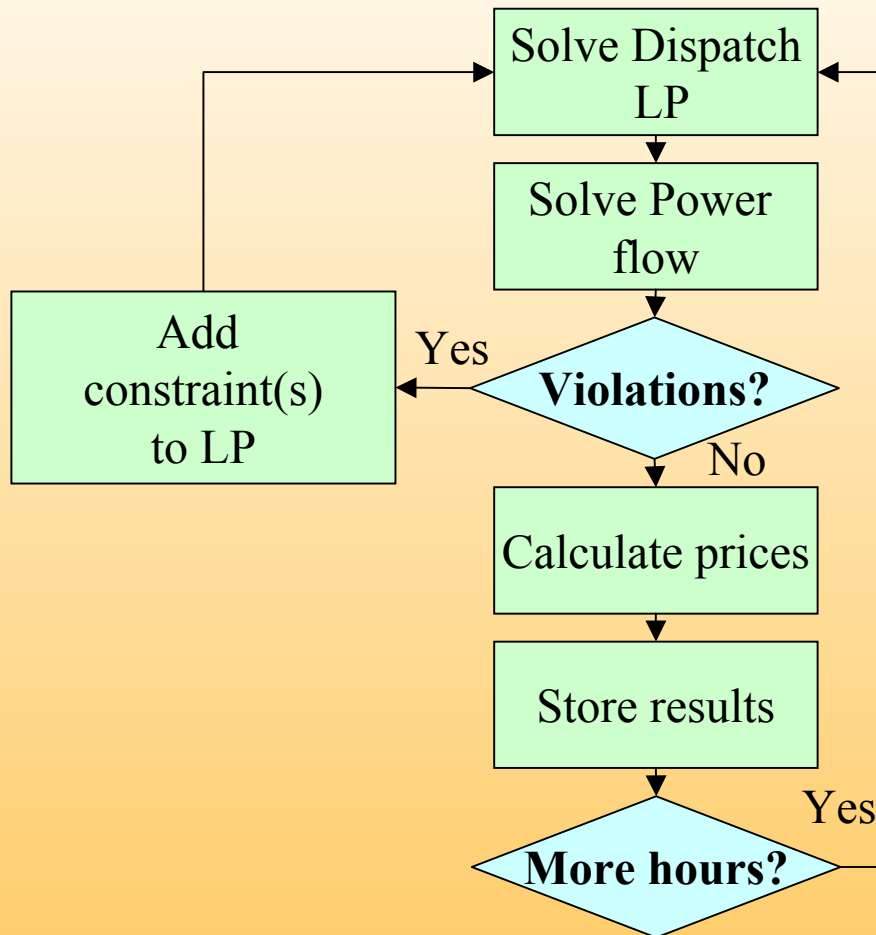


## ABB's Market Simulator

- DC optimal power flow.
- Full network model.
- Monitors flows on transmission lines and paths.
- Calculates LMPs, line flows, capacity factors, production cost with an hourly resolution.



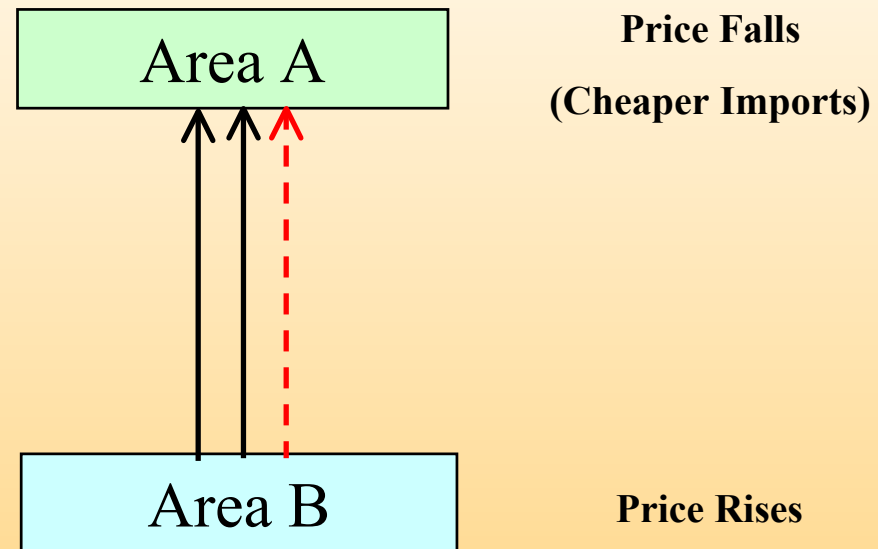
## ABB's Market Simulator





## Assessing Transmission Benefits

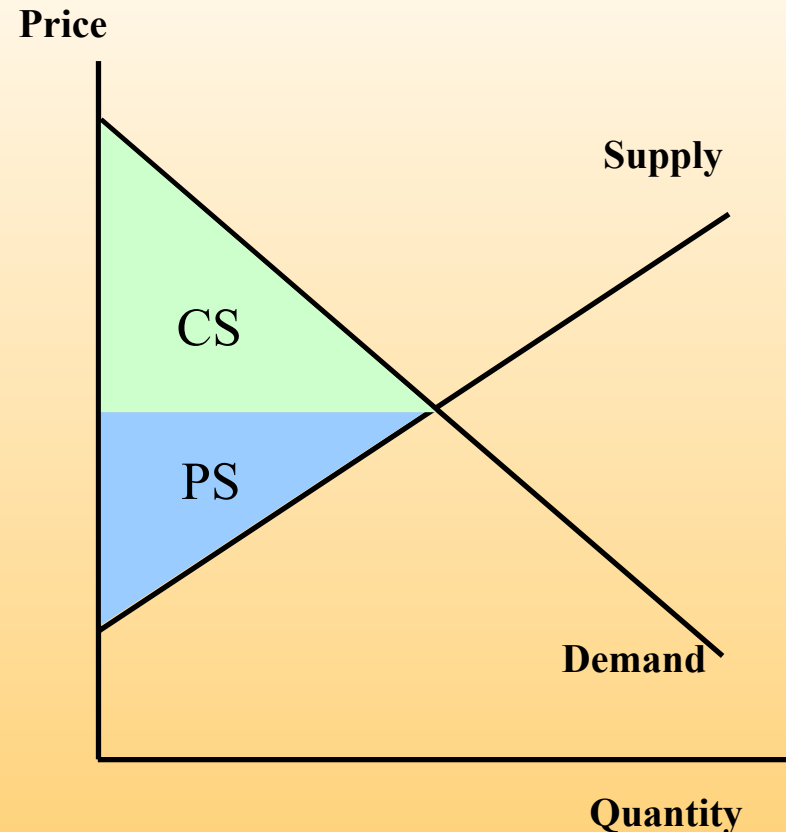
- Consumer benefit increases in A but decreases in B.
- Producer benefit increases in B but decreases in A.
- Total GROSS benefit should not be less than it was before the investment.
- Subtract cost of new line to assess total NET benefit.





## Assessing Transmission Benefits Producer and Consumer Surplus

- Consumer Surplus (CS) is the difference between willingness to pay, and payment, over all output.
- Producer Surplus is the difference between the total payment received and the total cost of production.
- Total Benefit (TB) = CS + PS





## Process

1. Use SSG-WI database as a starting point (No transmission additions).
2. Enforce all path and nomogram constraints and all 500 kV line limits.
3. Run ABB's Market Simulator for year 2008 to evaluate:
  - Production Cost = Total cost paid by each generation unit to produce its output for each hour, summed by area.
  - Producer Revenue = Total revenue collected by each generation unit which is the sum of hourly LMP\*hourly output for each hour, summed by area.
  - Producer Profit = Producer Revenue – Production Cost, for each area.
  - Demand Price = Total cost paid by the load which is the sum of hourly LMP\*hourly load for each hour, summed by area.
4. Record major path and line flows.



## Process

5. Add a transmission upgrade increment.
6. Rerun the Market Simulator.
7. Record new Production Cost, Producer Revenue, Producer Profit, and Demand Price for each area.
8. Calculate the change in Producer Surplus (PS) = New Producer Profit – Old Producer Profit.
9. Calculate the Consumer Surplus (CS) = Old Demand Price – New Demand Price.
10. Calculate Total Benefit = PS + CS
11. Go to step 5

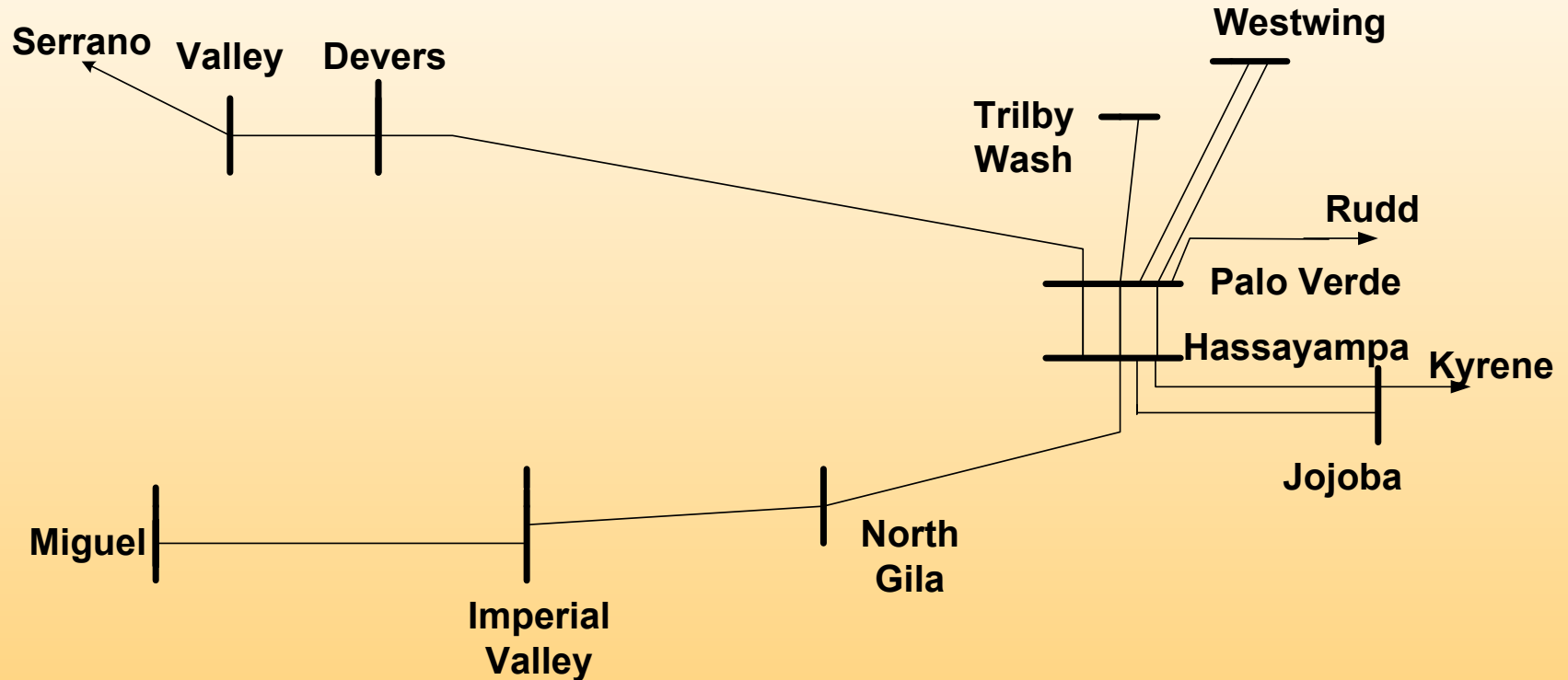


## What is not modeled

- Market Power
- Contracts
- Bids or exact heat rate data
- Low-voltage transmission line limits
- Transmission facilities cost



## Case 1: Transmission System Without Upgrade



# Case 1: Base Case

WOR - PV to Devers

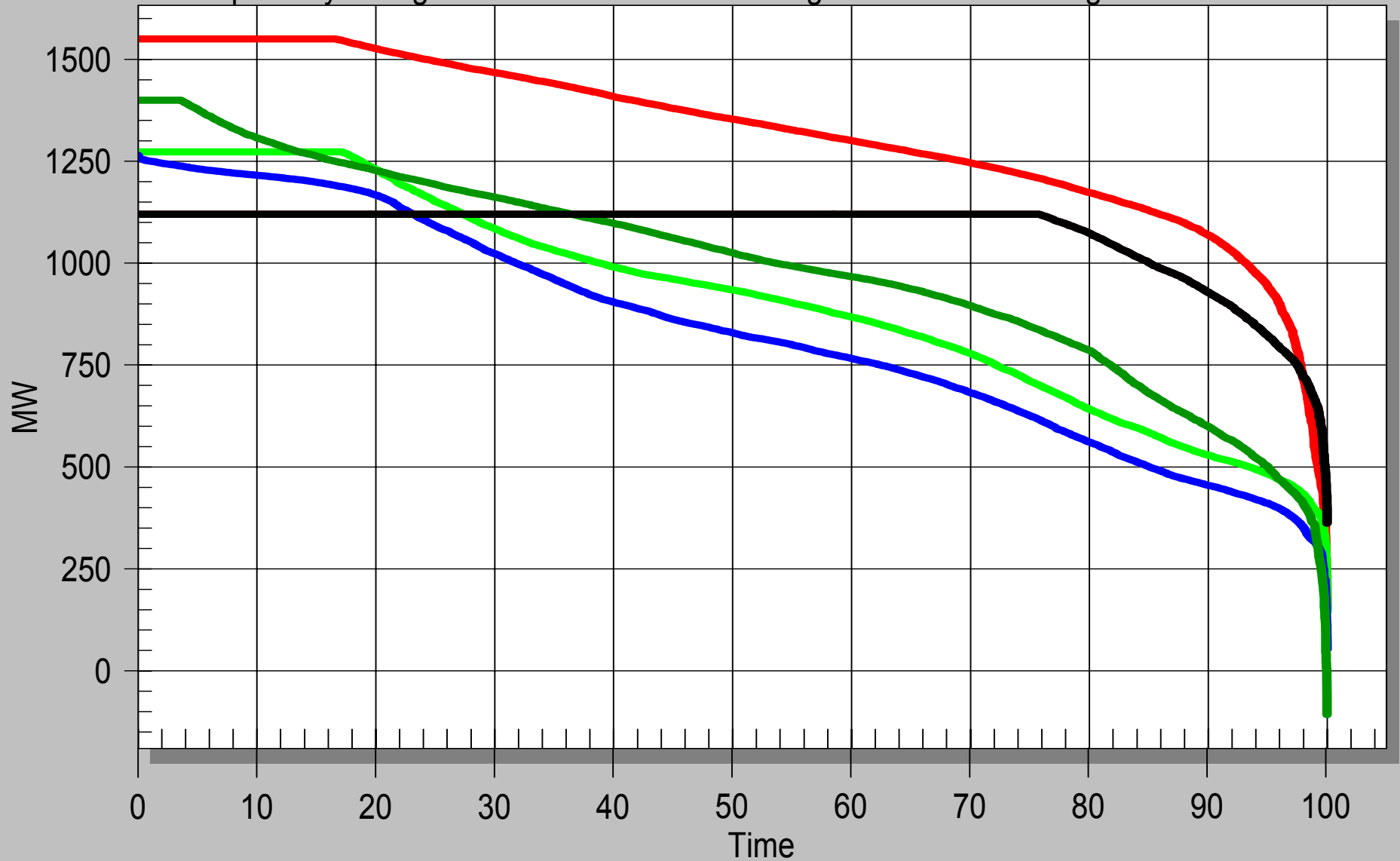
EOR - HASSYAMP- N.GILA

WOR - N.GILA - IMPRLVLY

Imp.Valley to Miguel 1

North of Miguel


Miguel Bank No. 1

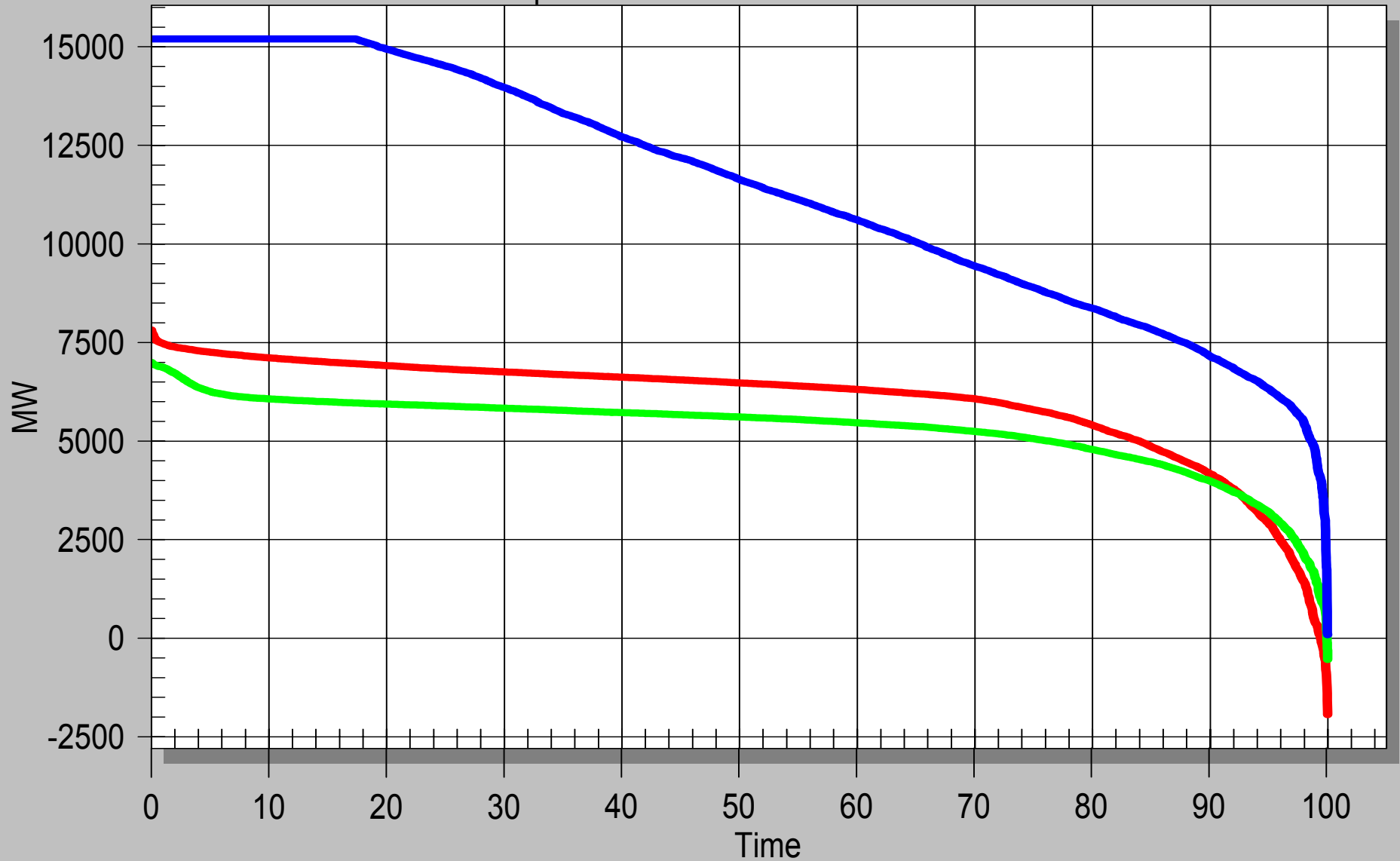


# Case 1: Base Case

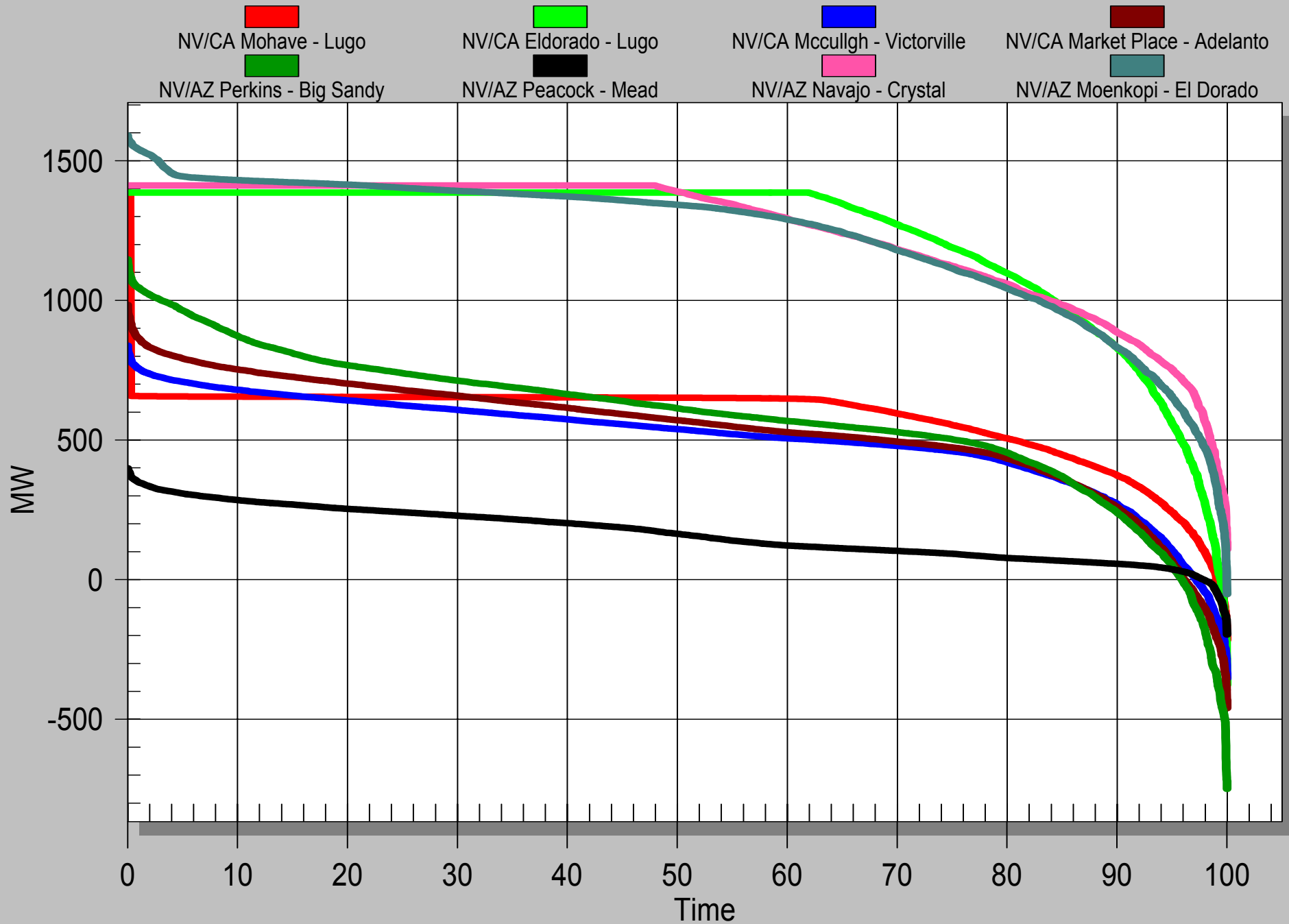
 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports



# Case 1: Base Case





## Case 1: Transmission System Without Upgrade

Name	Demand Price in K\$	Gen Revenue in k\$	Production Cost in k\$	Gen Profit in k\$
ARIZONA	\$3,286,465.00	\$4,692,649.00	\$2,593,633.52	\$2,099,015.48
NEVADA	\$998,349.00	\$898,055.00	\$711,393.42	\$186,661.58
WAPA L.C	\$81,868.00	\$635,675.00	\$347,801.80	\$287,873.20
MEXICO-C	\$640,629.00	\$563,480.00	\$313,198.81	\$250,281.19
IMPERIAL	\$148,566.00	\$131,634.00	\$24,641.10	\$106,992.90
SANDIEGO	\$893,018.00	\$417,723.00	\$384,458.00	\$33,265.00
SOCALIF	\$4,091,274.00	\$2,572,610.00	\$1,433,582.38	\$1,139,027.62
LADWP	\$1,205,502.00	\$789,337.00	\$515,882.88	\$273,454.12
PG AND E	\$5,395,626.00	\$4,536,159.00	\$2,118,260.71	\$2,417,898.29
Total WECC	\$34,718,282.00	\$33,769,814.00	\$13,682,792.57	\$20,087,021.43
ISO	\$10,379,918.00	\$7,526,492.00	\$3,936,301.09	\$3,590,190.91



## Common Upgrades

Case 2: Second Miguel 500/230 kV Bank with Imperial Valley – Miguel series capacitor upgrade.

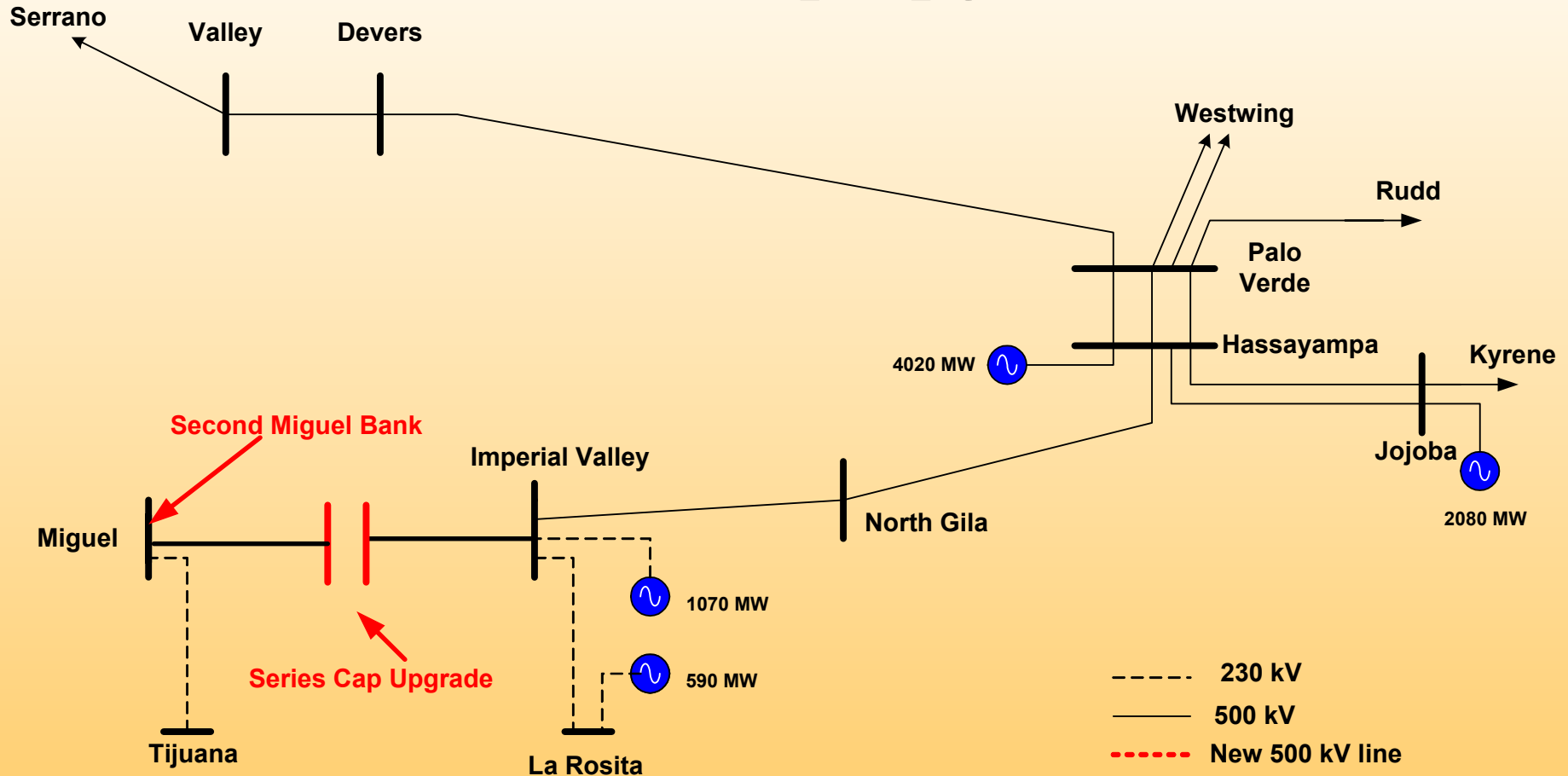
Case 3: Second Miguel – Mission 230 kV Line.

Case 4: Hassayampa – N. Gila – Imperial Valley series capacitor upgrade.

Case 5: Palo Verde – Devers series capacitor upgrade and second Devers 500/230 kV Bank.

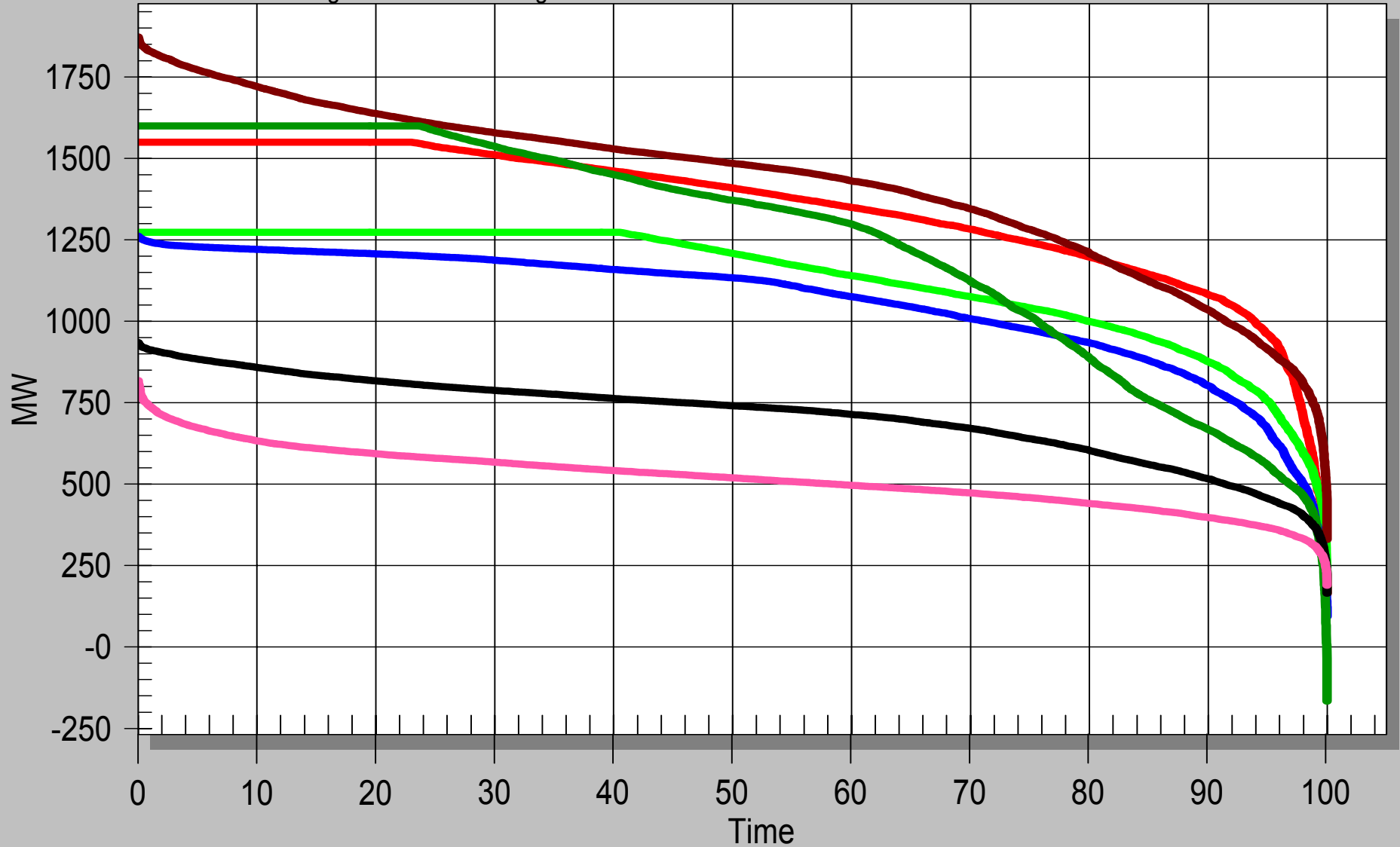
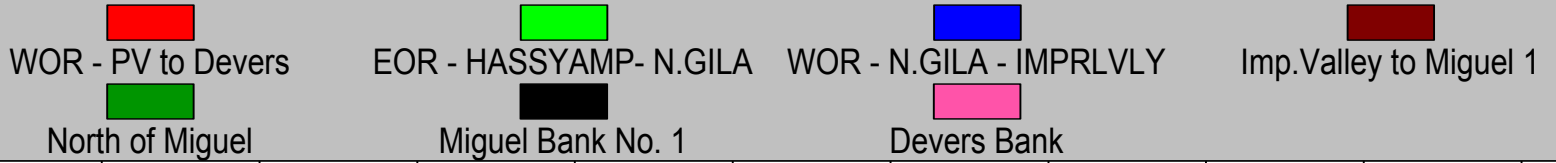


## Case 2: Second Miguel Bank and IV – MGL Series Cap Upgrade




# Case 2: Second ML Bank with IV - Miguel Series Cap Upgrade


Without Enforcing EOR, WOR or SCIT

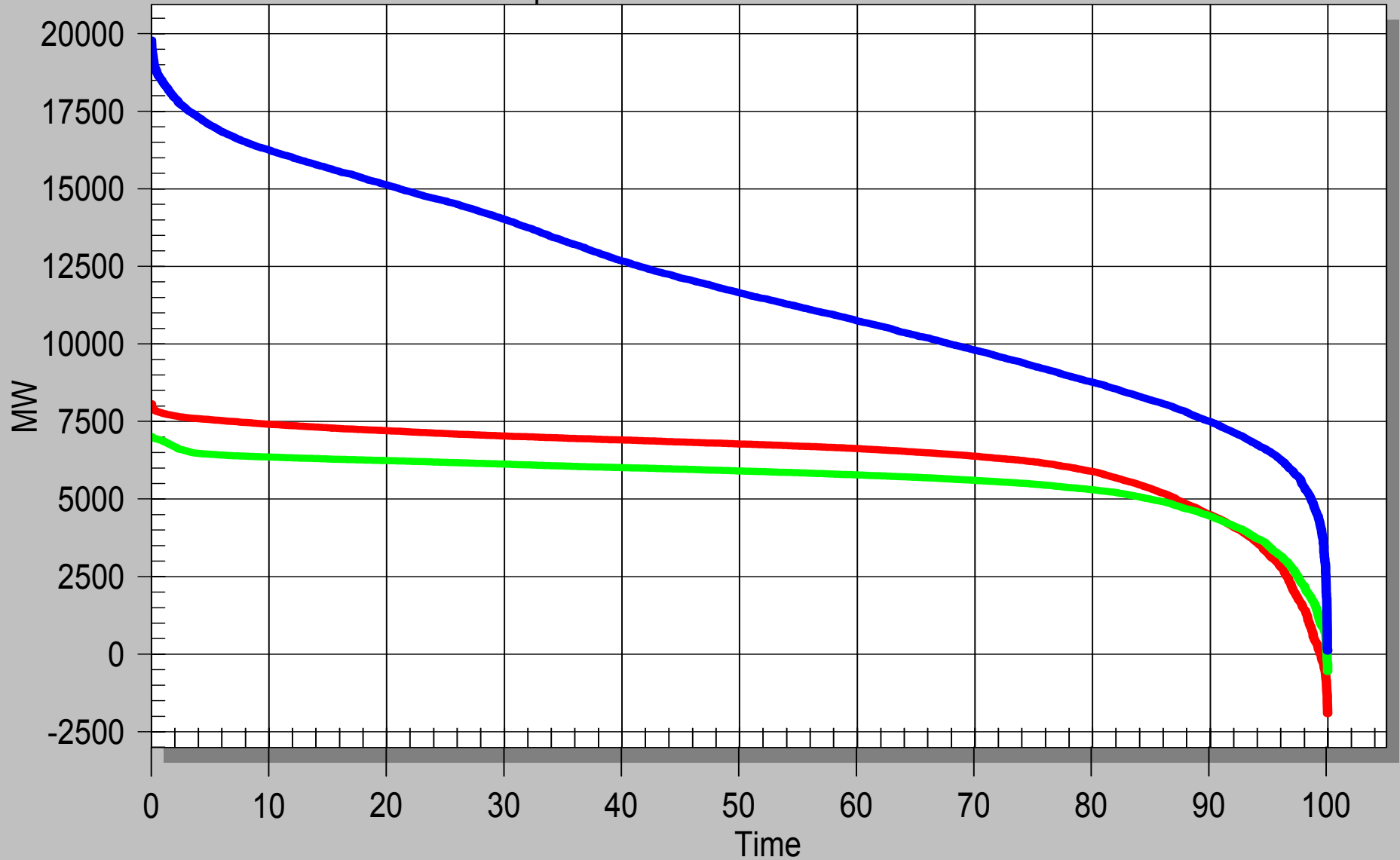


# Case 2: Second ML Bank with IV - ML Series Cap Upgrade

 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

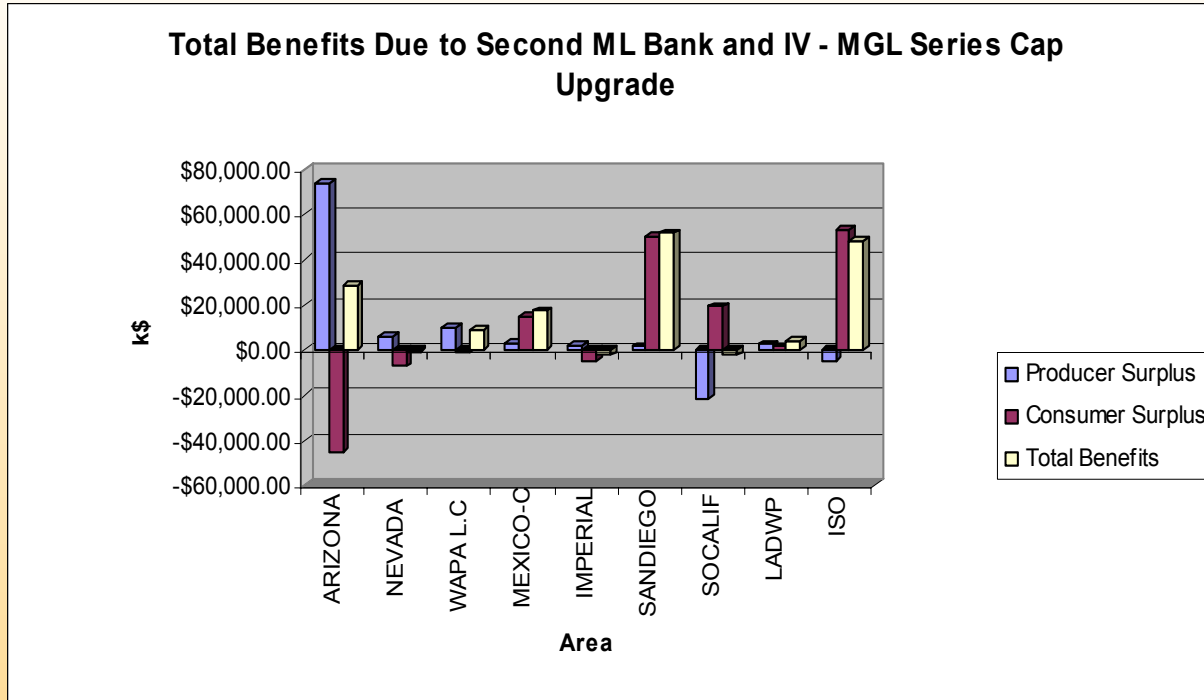
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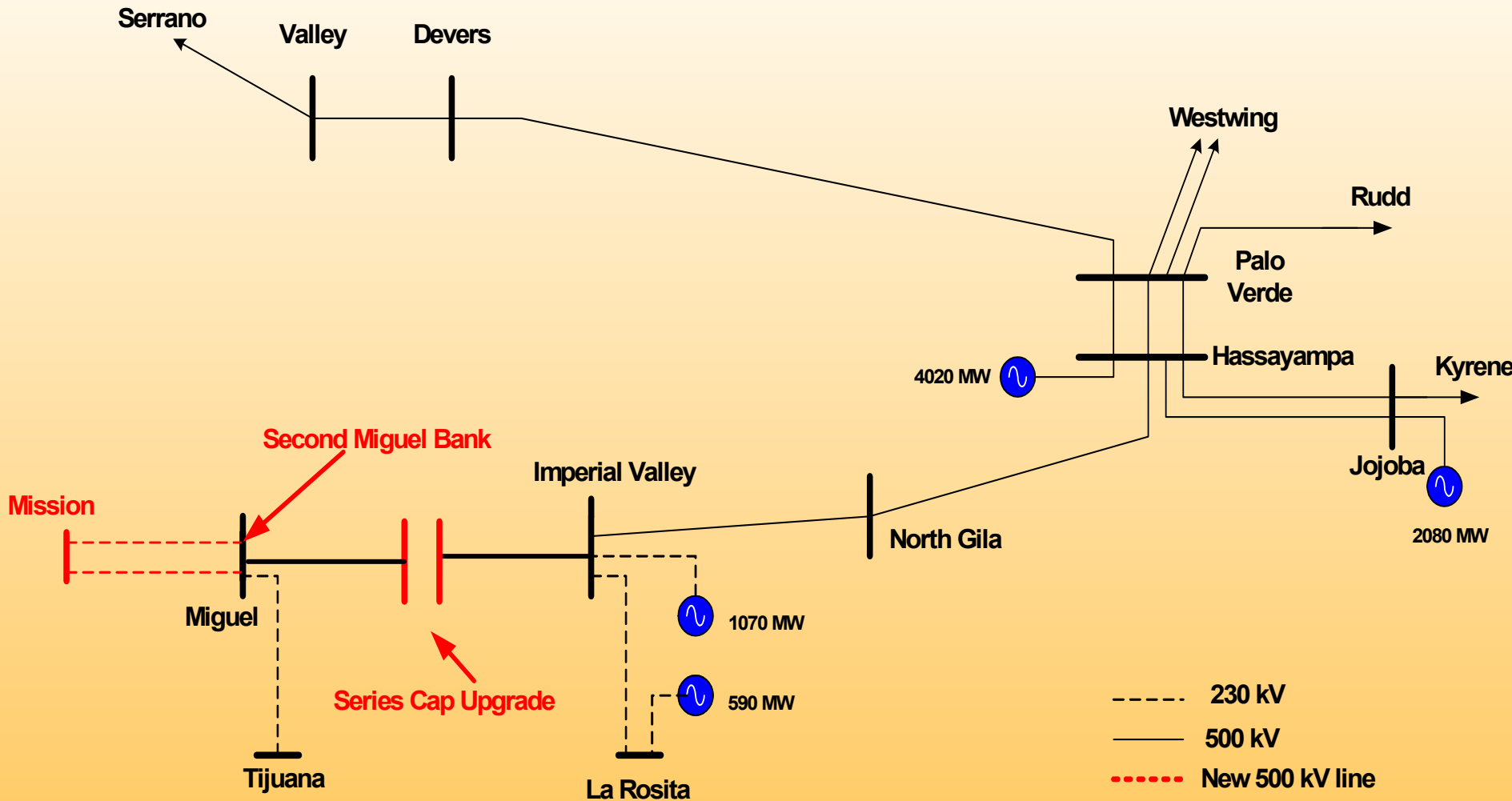
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	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
<b>PS</b>	\$74,075.03	\$6,176.61	\$9,696.10	\$2,848.51	\$2,487.30	\$1,672.89	-\$21,508.24	\$2,699.30	\$15,296.09	\$153,239.41	-\$4,539.25
<b>CS</b>	-\$45,099.00	-\$7,249.00	-\$929.00	\$14,556.00	-\$4,847.00	\$50,075.00	\$19,242.00	\$1,584.00	-\$16,415.00	-\$43,358.00	\$52,902.00
<b>TB</b>	\$28,976.03	-\$1,072.39	\$8,767.10	\$17,404.51	-\$2,359.70	\$51,747.89	-\$2,266.24	\$4,283.30	-\$1,118.91	\$109,881.41	\$48,362.75



## Case 3: Second Miguel – Mission 230 kV Line



# Case 3: Second ML - MS

WOR - PV to Devers



EOR - HASSYAMP- N.GILA



WOR - N.GILA - IMPRLVLY



Imp.Valley to Miguel 1



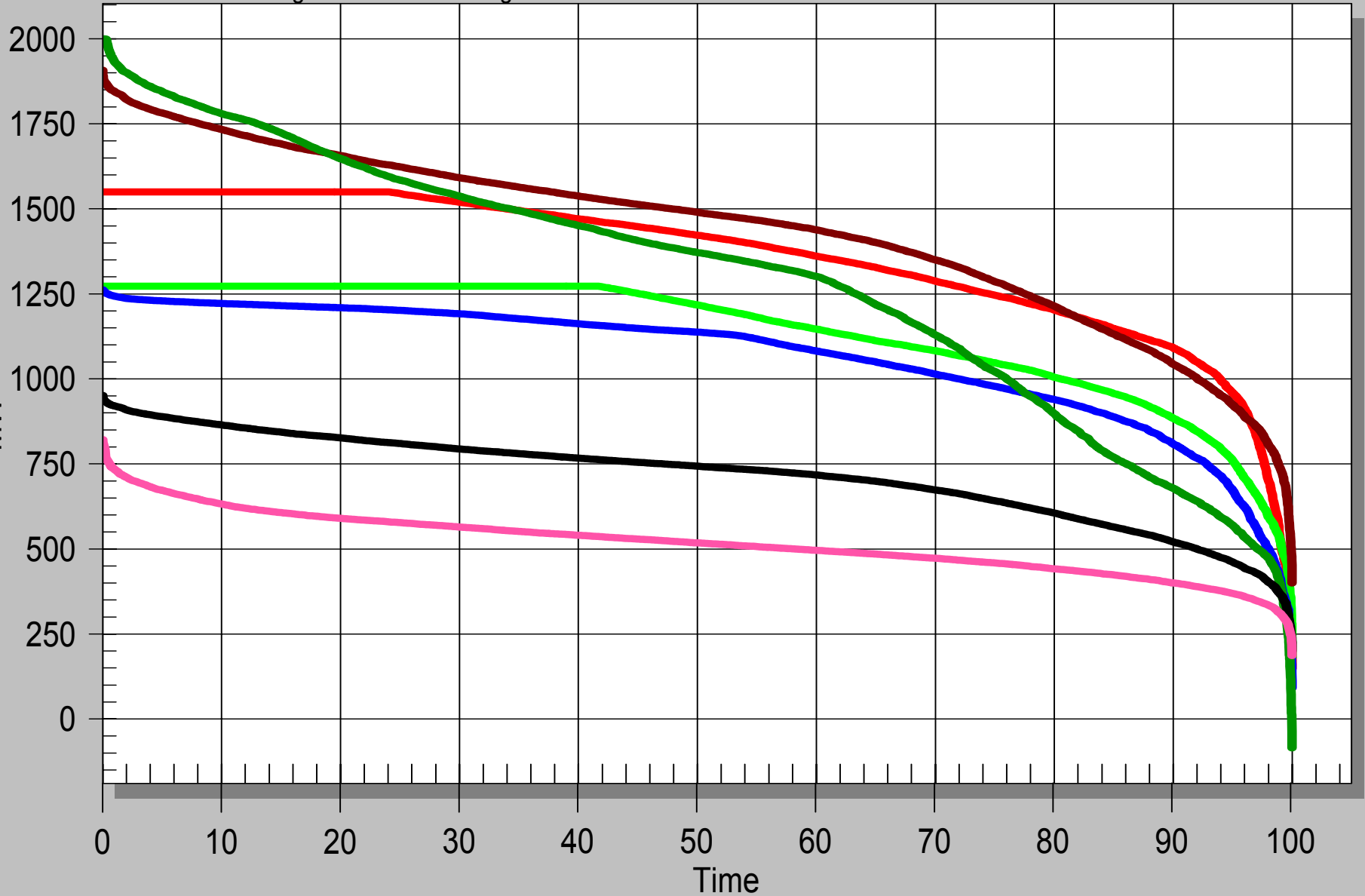
North of Miguel



Miguel Bank No. 1




Devers Bank

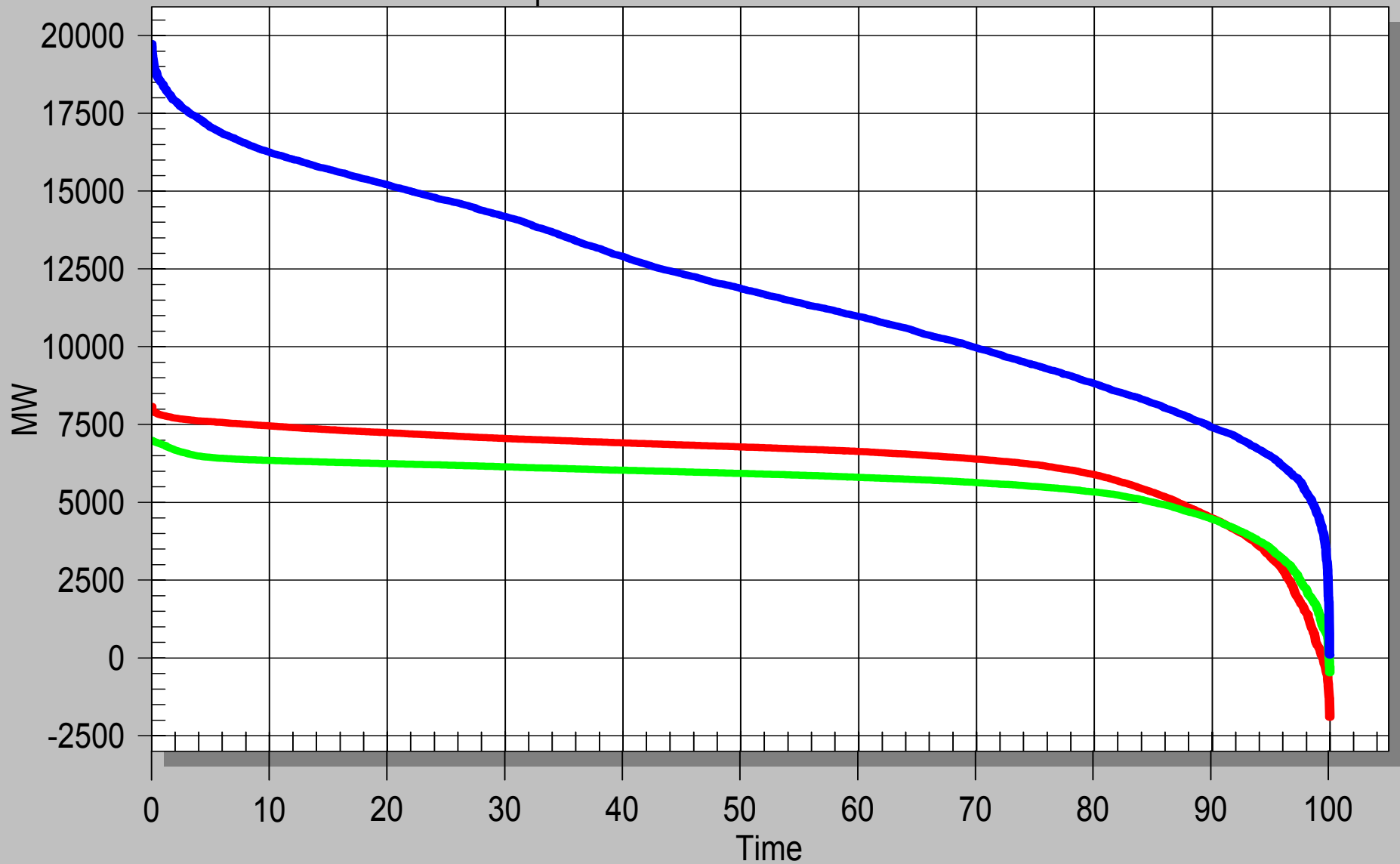


# Case 3: Second ML-MS

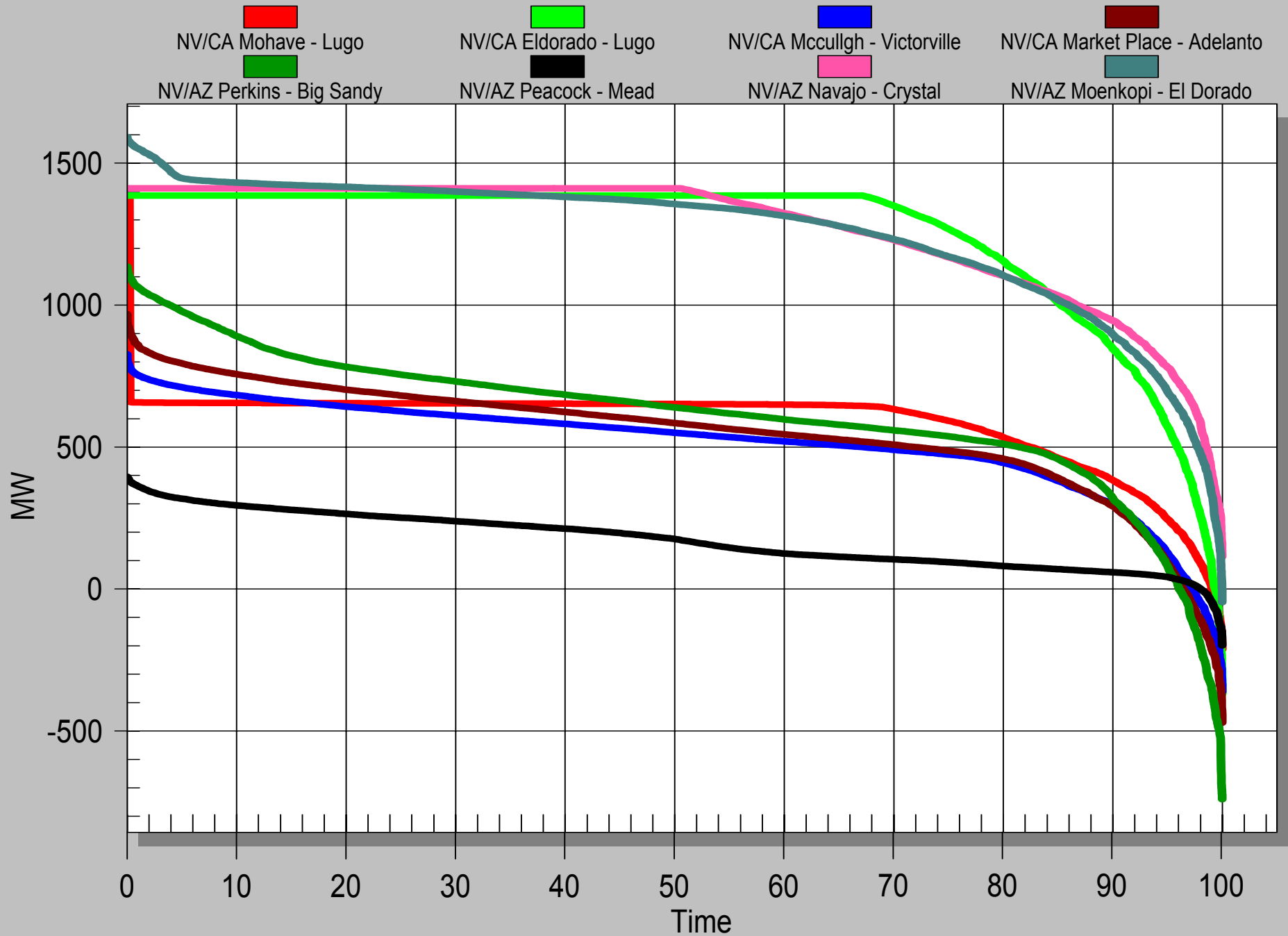
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# Case 3: Second ML - MS

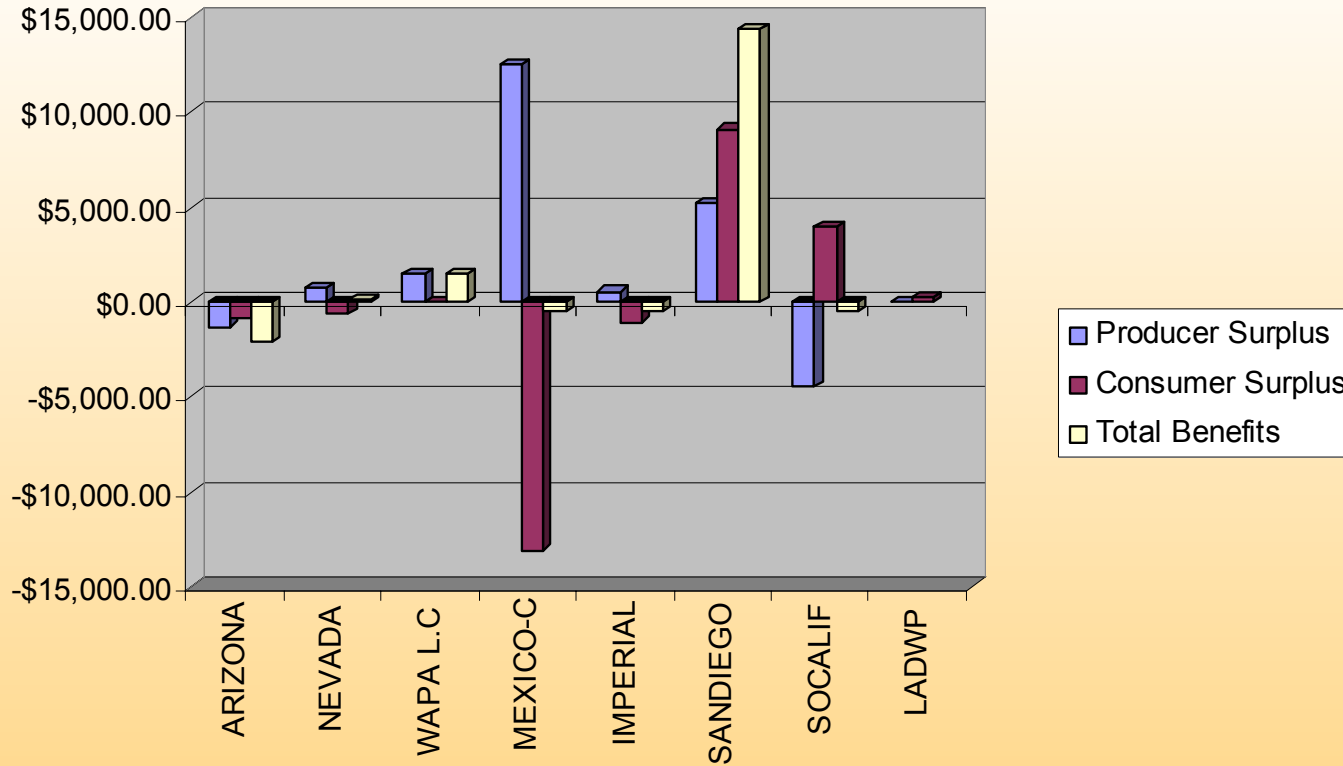




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## Incremental Benefits Due to Second Miguel – Mission 230 kV Line



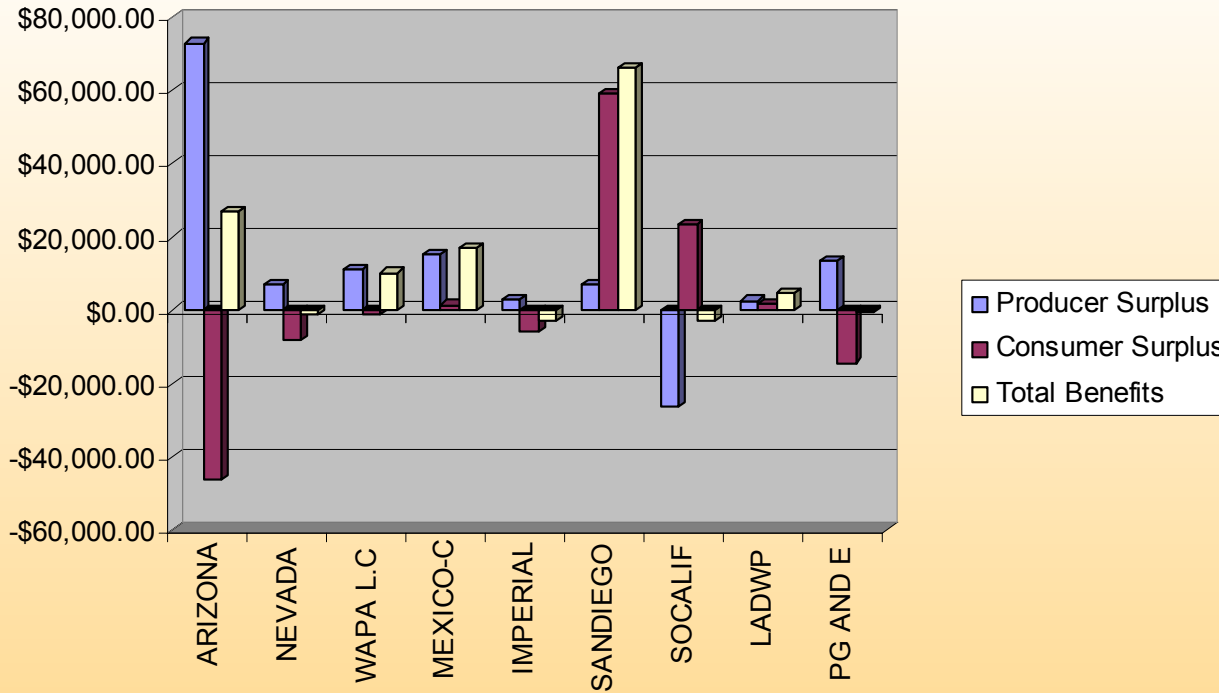
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	-\$1,285.58	\$753.60	\$1,462.61	\$12,544.90	\$545.60	\$5,241.91	-\$4,488.48	\$16.60	-\$1,594.07	\$2,010.33	-\$840.64
CS	-\$849.00	-\$621.00	\$28.00	-\$13,060.00	-\$1,052.00	\$9,129.00	\$3,990.00	\$233.00	\$2,209.00	\$9,568.00	\$15,328.00
TB	-\$2,134.58	\$132.60	\$1,490.61	-\$515.10	-\$506.40	\$14,370.91	-\$498.48	\$249.60	\$614.93	\$11,578.33	\$14,487.36



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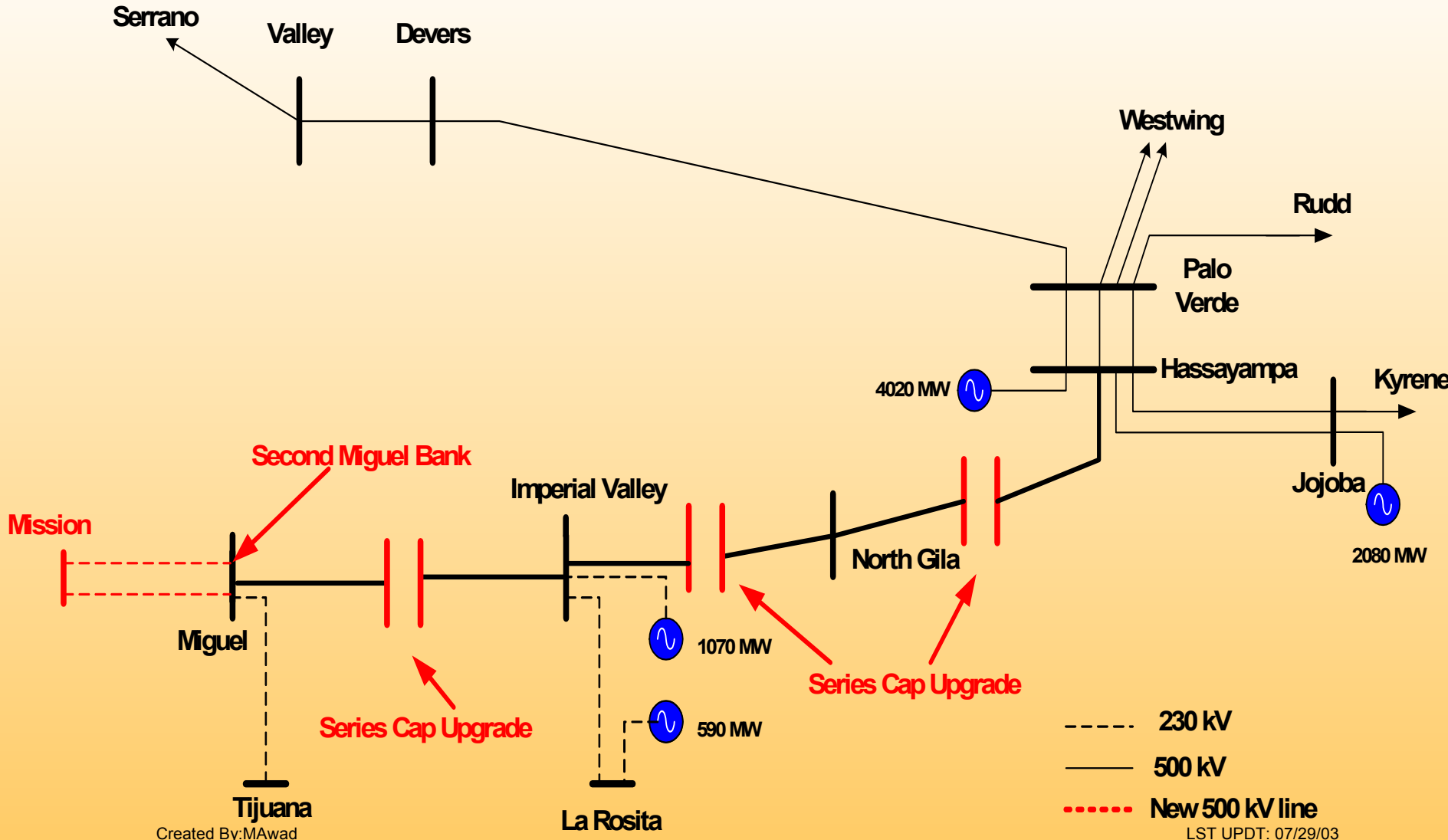
## Total Benefits Up to Second Miguel – Mission 230 kV Line



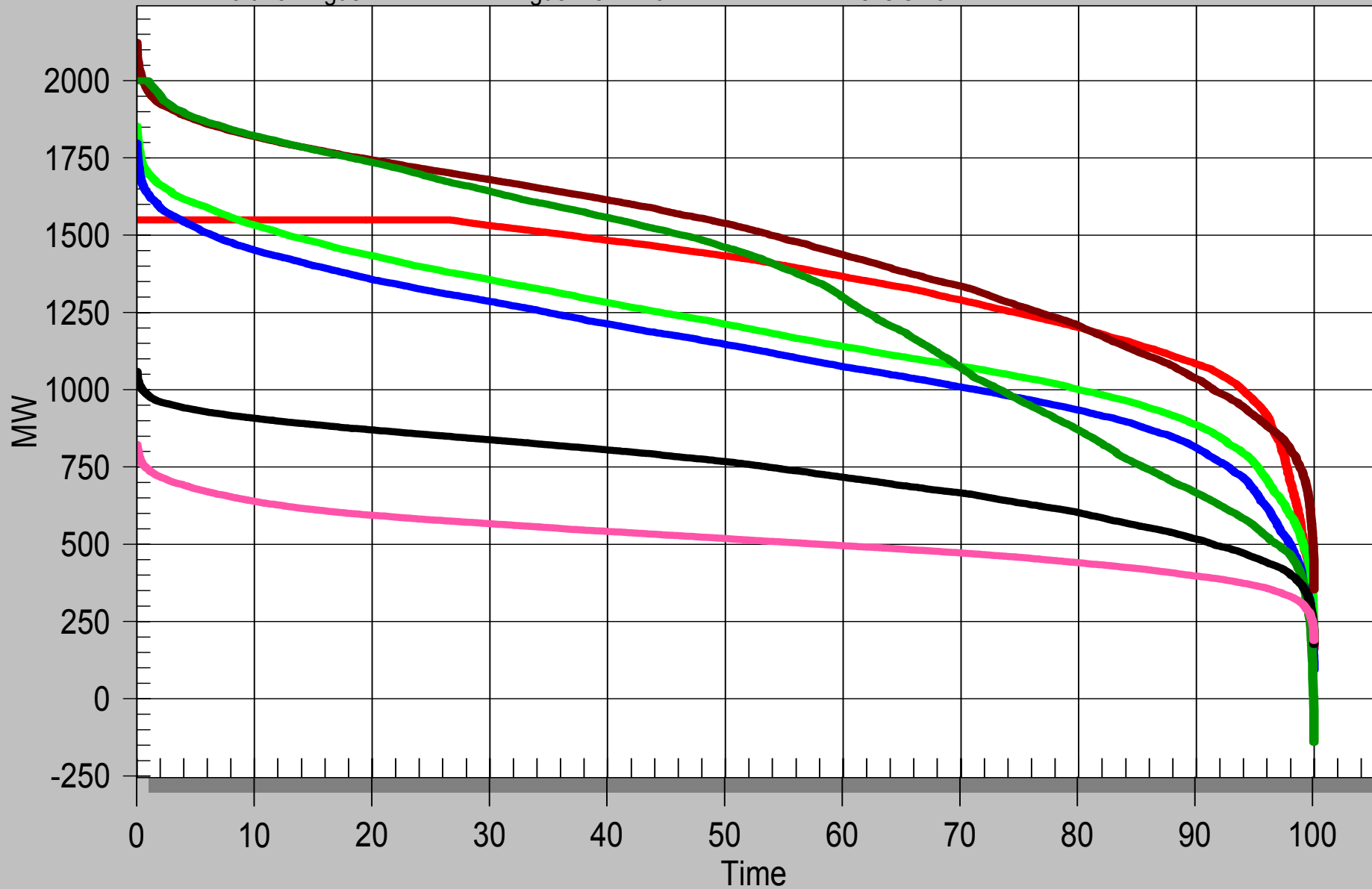
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$72,789.45	\$6,930.21	\$11,158.71	\$15,393.41	\$3,032.90	\$6,914.80	-\$25,996.72	\$2,715.90	\$13,702.02	\$155,249.73	-\$5,379.89
CS	-\$45,948.00	-\$7,870.00	-\$901.00	\$1,496.00	-\$5,899.00	\$59,204.00	\$23,232.00	\$1,817.00	-\$14,206.00	-\$33,790.00	\$68,230.00
TB	\$26,841.45	-\$939.79	\$10,257.71	\$16,889.41	-\$2,866.10	\$66,118.80	-\$2,764.72	\$4,532.90	-\$503.98	\$121,459.73	\$62,850.11



## Case 4: Hassayampa – IV Series Cap Upgrade





# Case 4: HAS - IV Series Cap Upgrade

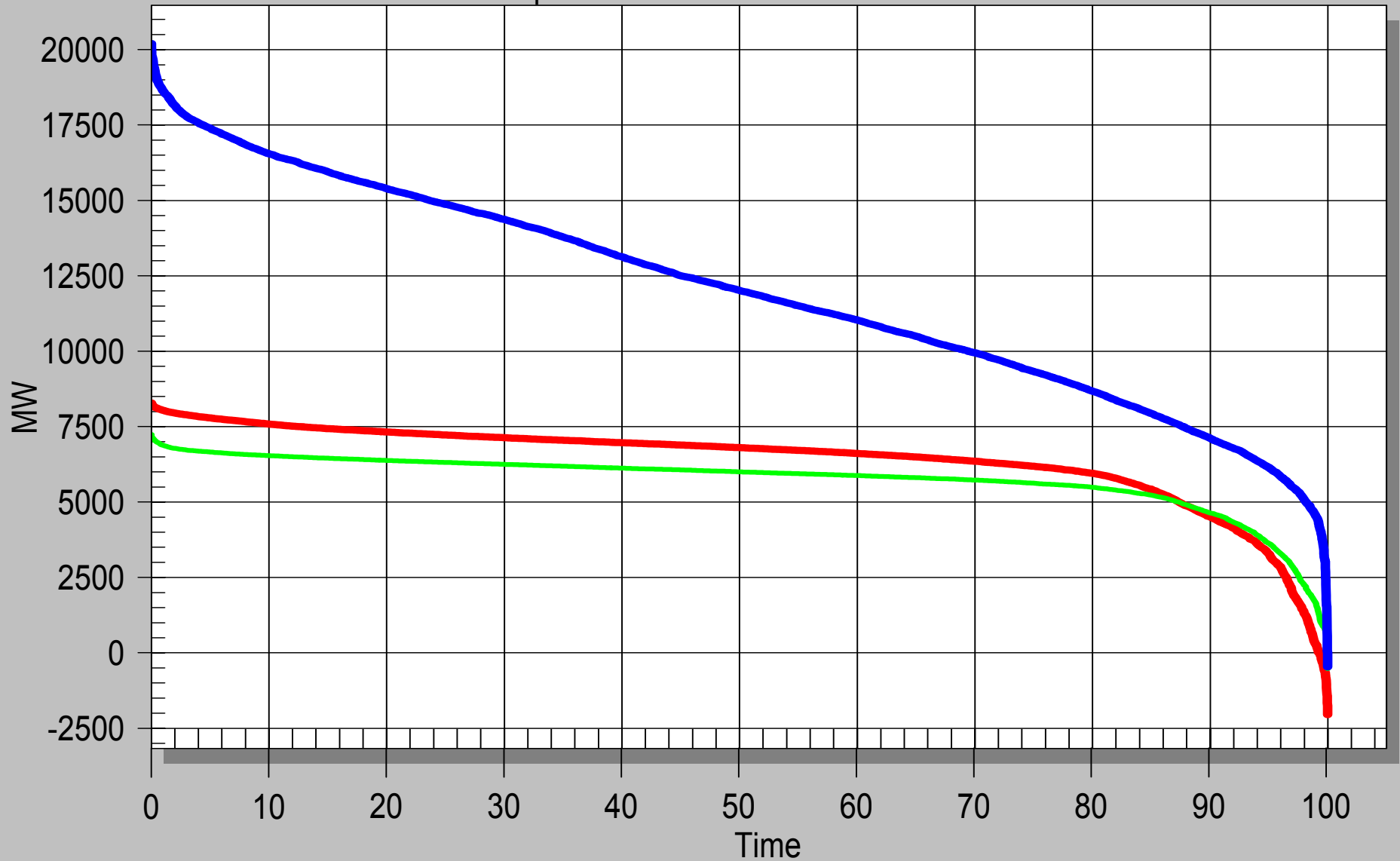


# Case 4:HAS - IV Series Cap Upgrade

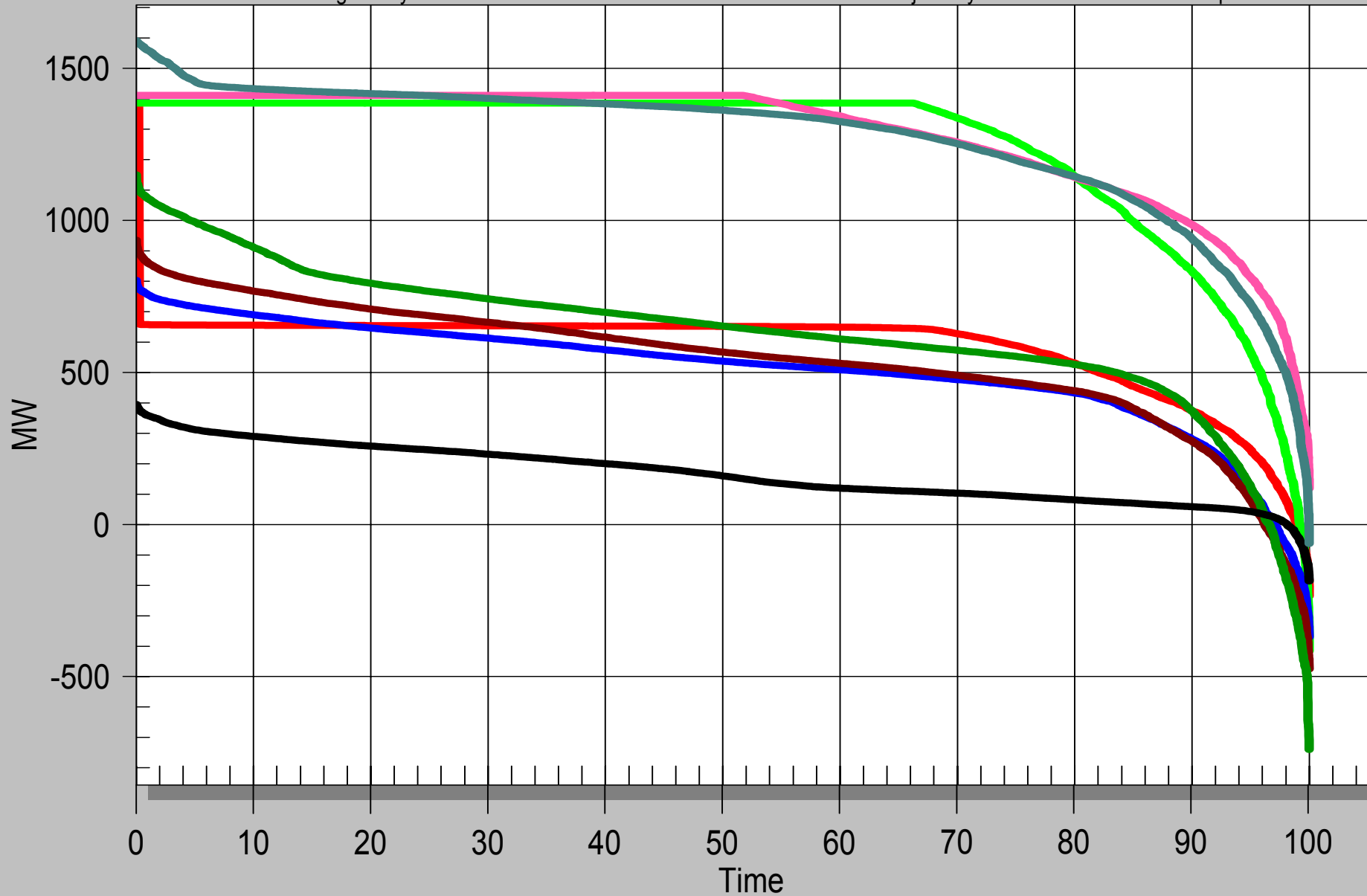
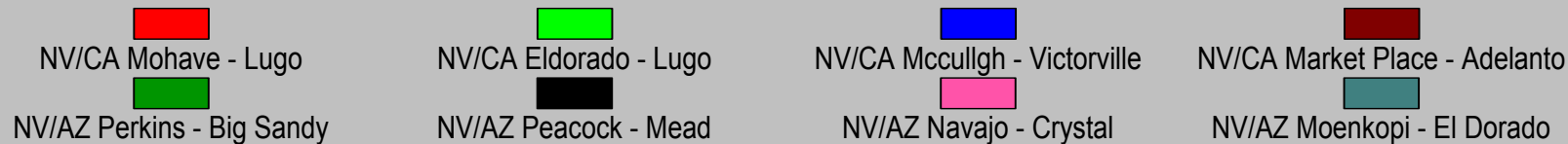
 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports



# Case 4: HAS - IV Series Cap Upgrade

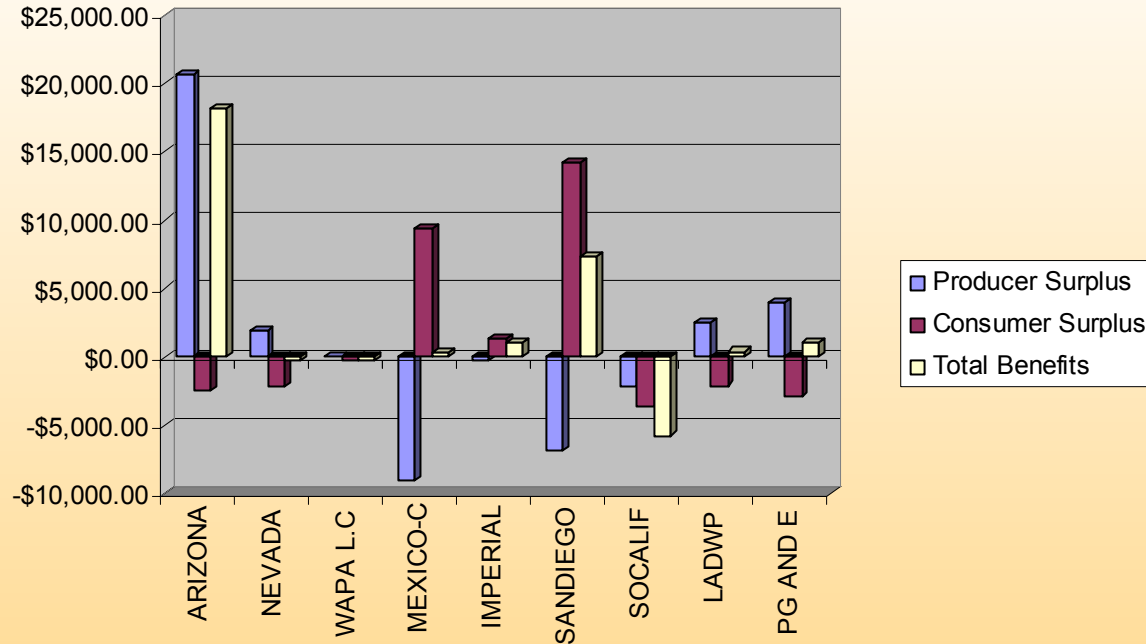




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## Incremental Benefits Due to HAS – IV Series Cap Upgrade



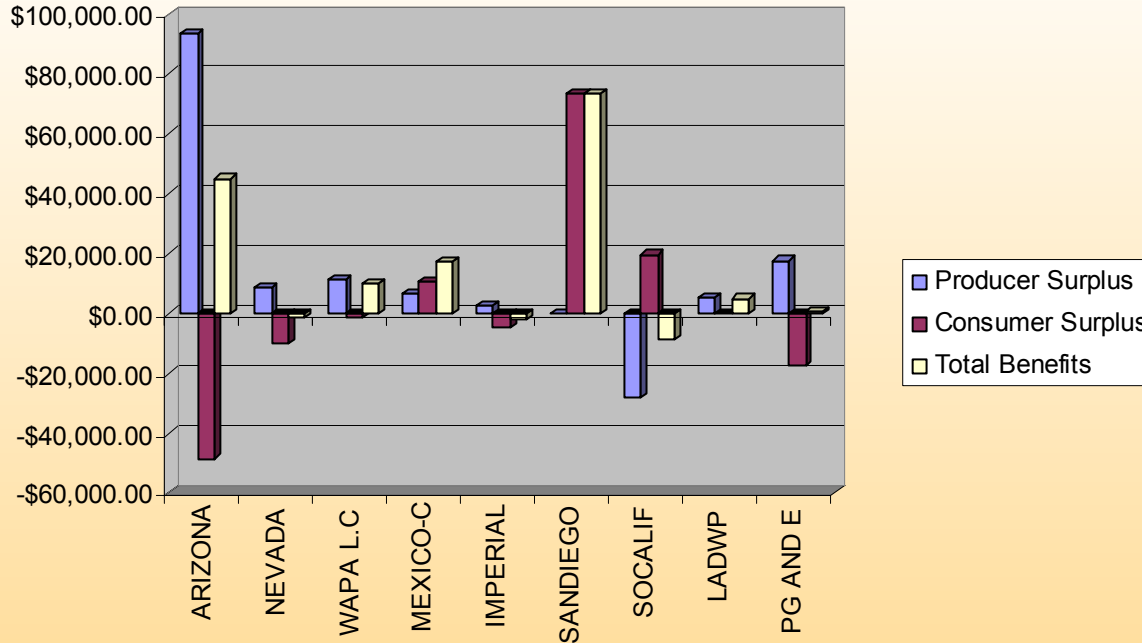
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$20,647.47	\$1,909.60	\$12.50	-\$9,006.40	-\$281.60	-\$6,752.00	-\$2,176.20	\$2,485.00	\$3,957.40	\$24,733.21	-\$4,970.80
CS	-\$2,446.00	-\$2,125.00	-\$237.00	\$9,392.00	\$1,398.00	\$14,168.00	-\$3,543.00	-\$2,059.00	-\$2,902.00	\$3,340.00	\$7,723.00
TB	\$18,201.47	-\$215.40	-\$224.50	\$385.60	\$1,116.40	\$7,416.00	-\$5,719.20	\$426.00	\$1,055.40	\$28,073.21	\$2,752.20



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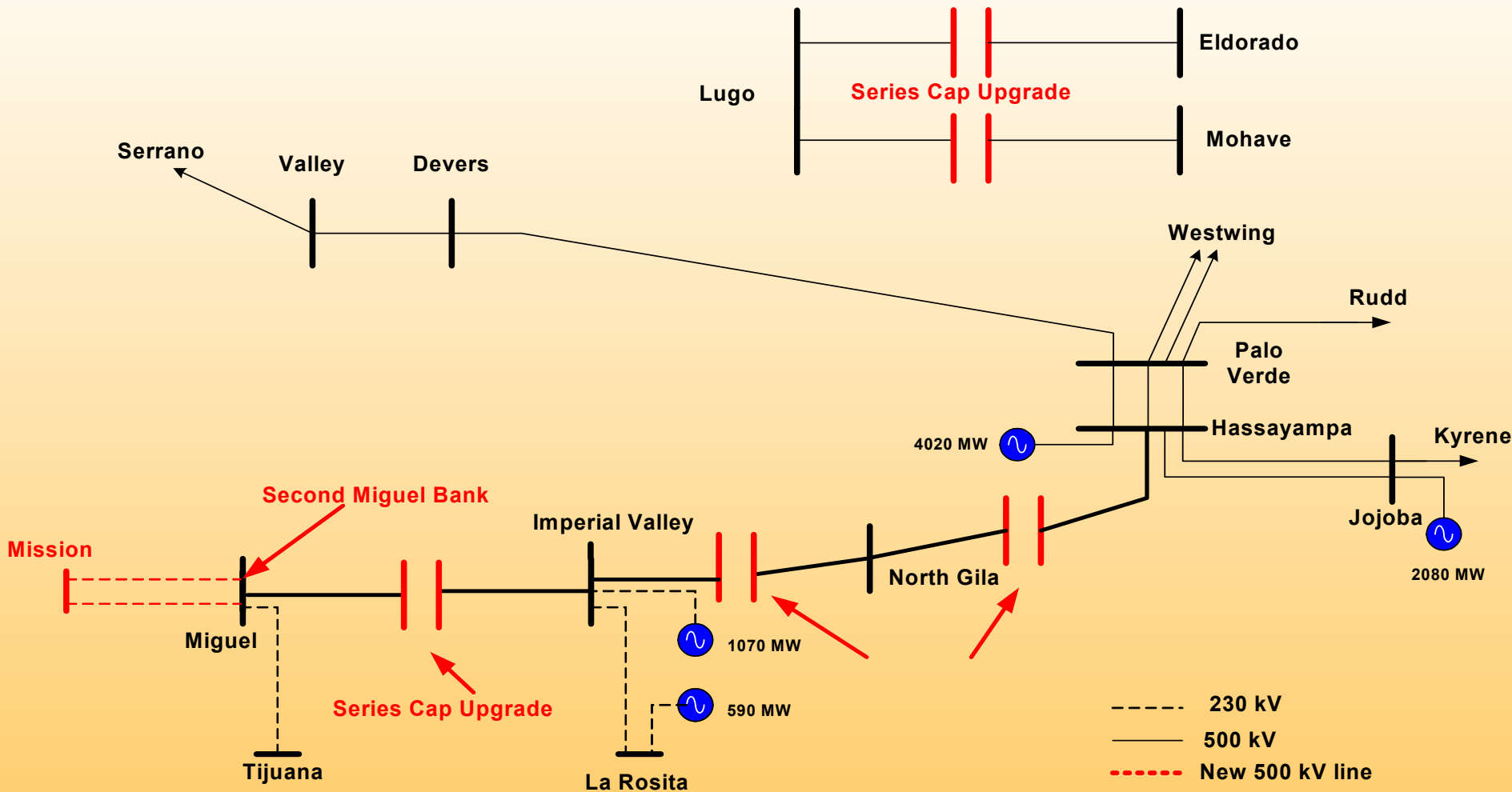
## Accumulative Benefits Up to HAS – IV Series Cap Upgrade



	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$93,436.92	\$8,839.82	\$11,171.21	\$6,387.01	\$2,751.30	\$162.80	-\$28,172.91	\$5,200.90	\$17,659.42	\$179,982.94	-\$10,350.69
CS	-\$48,394.00	-\$9,995.00	-\$1,138.00	\$10,888.00	-\$4,501.00	\$73,372.00	\$19,689.00	-\$242.00	-\$17,108.00	-\$30,450.00	\$75,953.00
TB	\$45,042.92	-\$1,155.18	\$10,033.21	\$17,275.01	-\$1,749.70	\$73,534.80	-\$8,483.91	\$4,958.90	\$551.42	\$149,532.94	\$65,602.31





## Case 4b: CA/NV Series Cap Upgrade

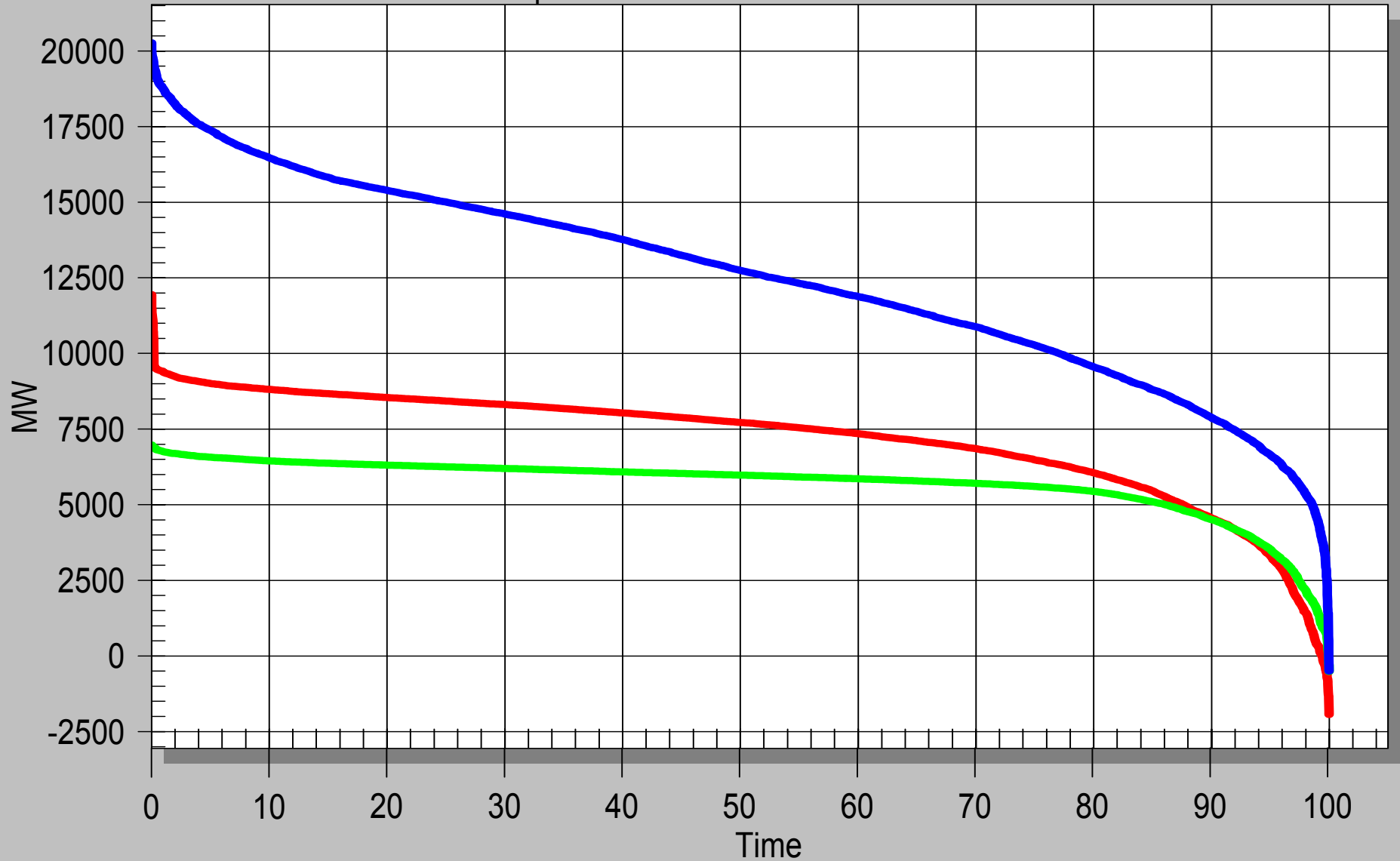


# Case 4b: HAS - IV Series Cap Upgrade

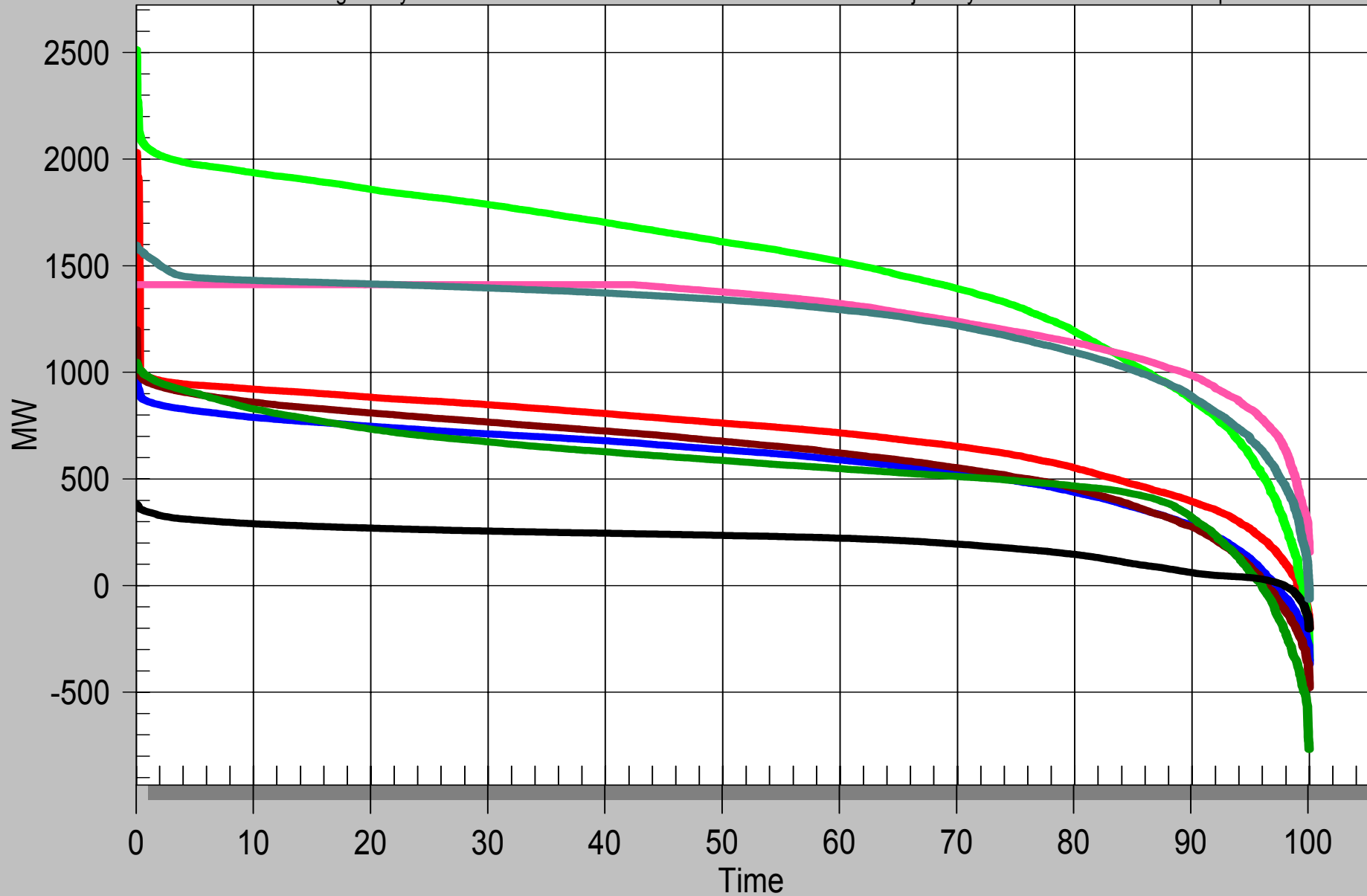
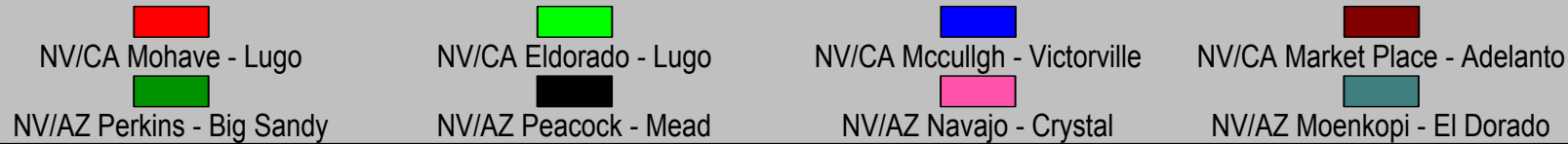
 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports



# Case 4b: HAS - IV Series Cap Upgrade

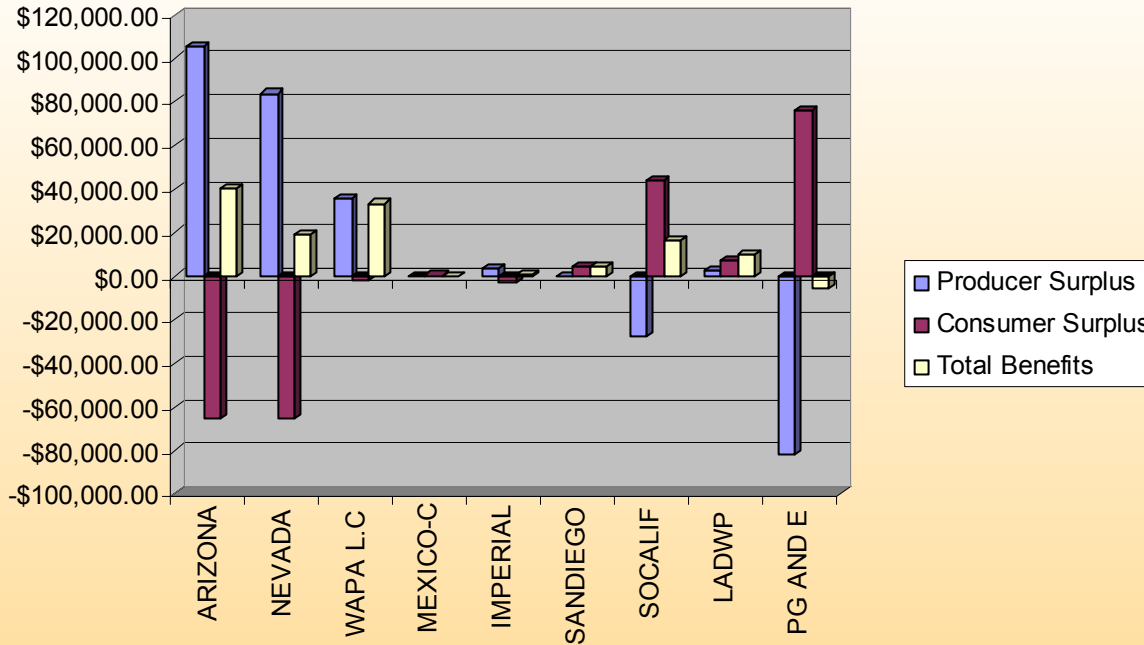




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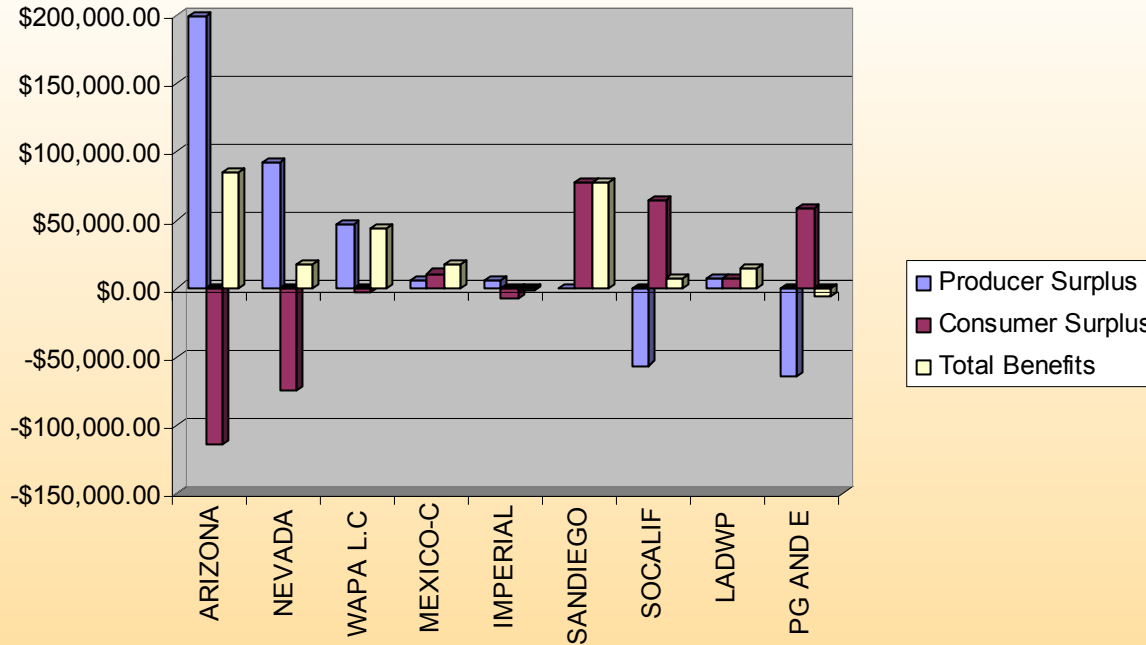
## Incremental Benefits Due to CA/NV Tie Series Cap Upgrade



	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$105,334.11	\$83,853.90	\$35,551.30	-\$35.10	\$3,235.60	\$241.00	-\$27,801.50	\$2,854.20	-\$81,461.52	\$92,654.35	-\$109,022.02
CS	-\$65,413.00	-\$64,909.00	-\$2,096.00	\$327.00	-\$2,764.00	\$4,284.00	\$44,198.00	\$7,130.00	\$75,824.00	\$18,052.00	\$124,306.00
TB	\$39,921.11	\$18,944.90	\$33,455.30	\$291.90	\$471.60	\$4,525.00	\$16,396.50	\$9,984.20	-\$5,637.52	\$110,706.35	\$15,283.98



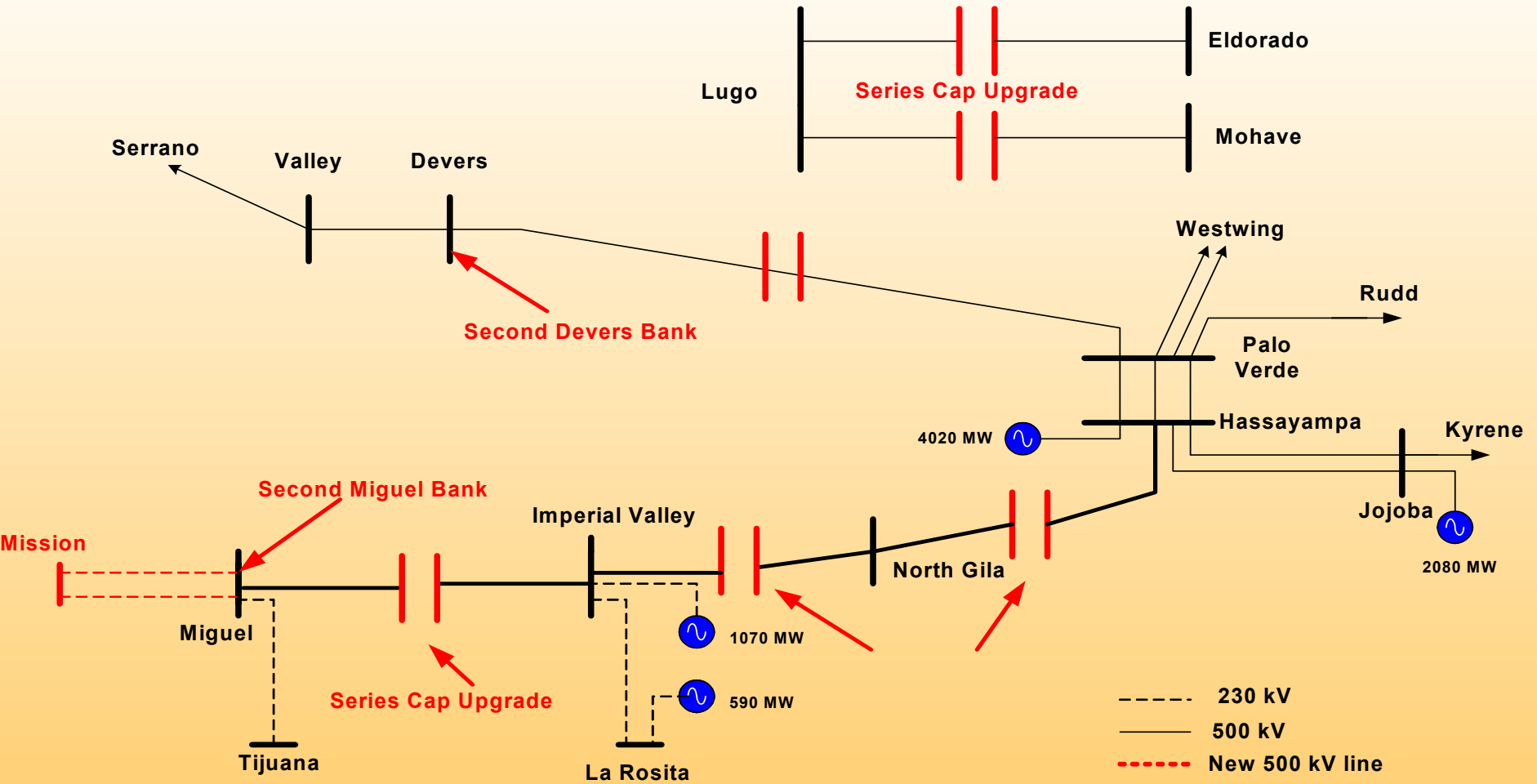
## Total Benefits Up to CA/NV Tie Series Cap Upgrade



	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$198,771.04	\$92,693.72	\$46,722.51	\$6,351.91	\$5,986.90	\$403.80	-\$55,974.42	\$8,055.09	-\$63,802.10	\$272,637.29	-\$119,372.71
CS	-\$113,807.00	-\$74,904.00	-\$3,234.00	\$11,215.00	-\$7,265.00	\$77,656.00	\$63,887.00	\$6,888.00	\$58,716.00	-\$12,398.00	\$200,259.00
TB	\$84,964.04	\$17,789.72	\$43,488.51	\$17,566.91	-\$1,278.10	\$78,059.80	\$7,912.58	\$14,943.09	-\$5,086.10	\$260,239.29	\$80,886.29

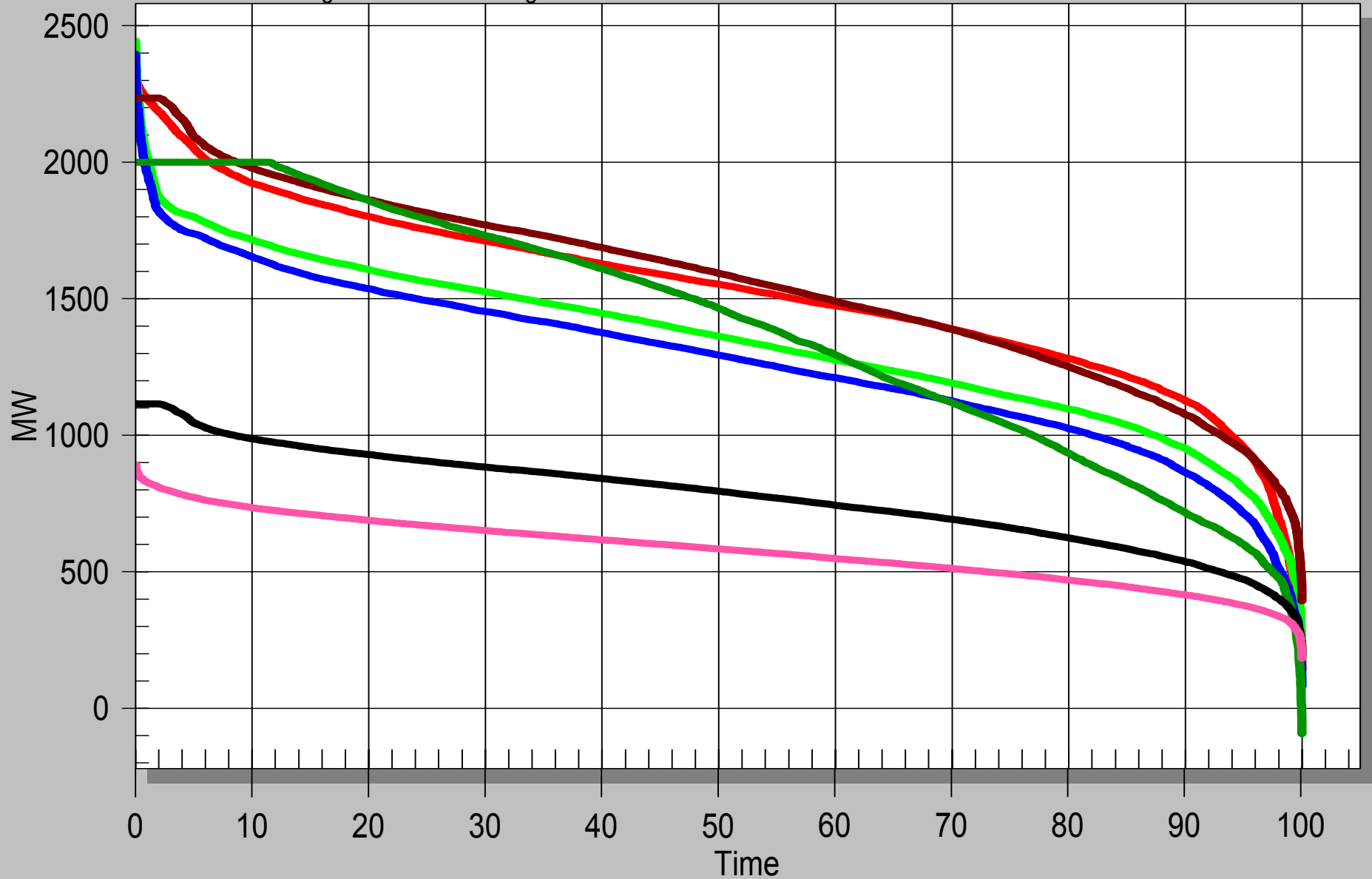


## Case 5b: Palo Verde - Devers Series Cap Upgrade



# Case 5b: PVD Series Cap Upgrade

WOR - PV to Devers  
EOR - HASSYAMP- N.GILA  
WOR - N.GILA - IMPRLVLY  
Imp.Valley to Miguel 1  
North of Miguel  
Miguel Bank No. 1  
Devers Bank

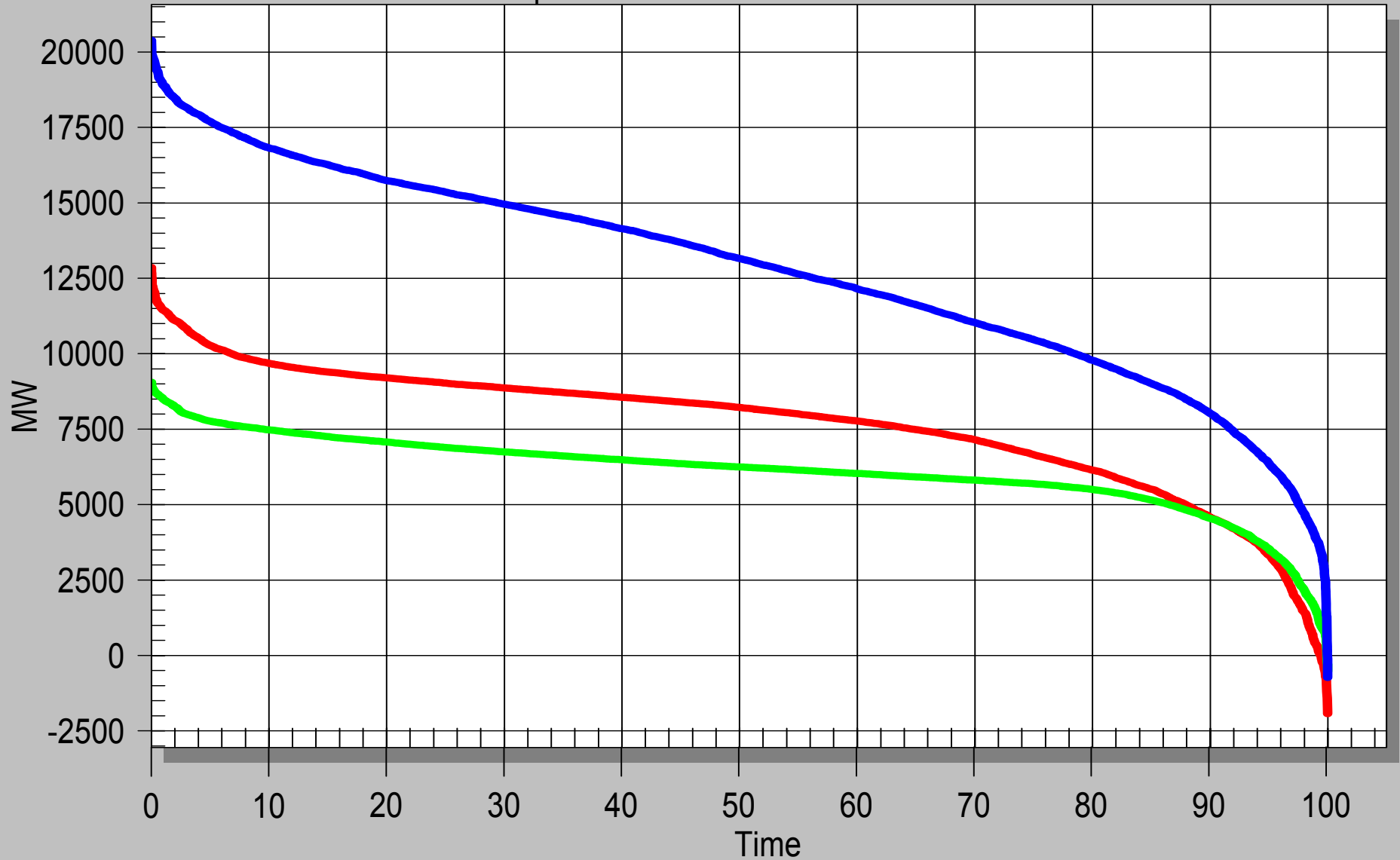


# Case 5b: PVD Series Cap Upgrade

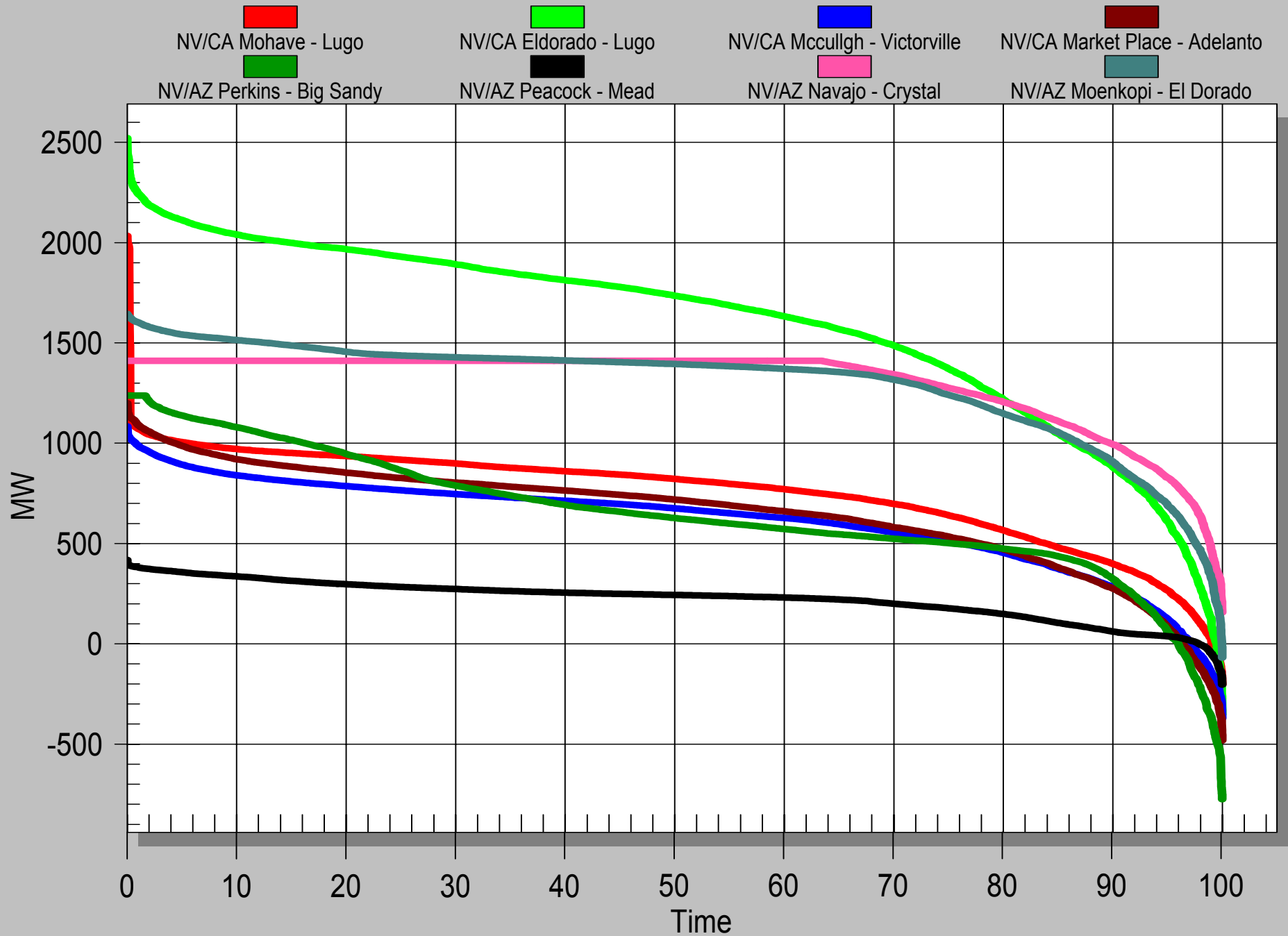
 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports



# Case 5b: PVD Series Cap Upgrade

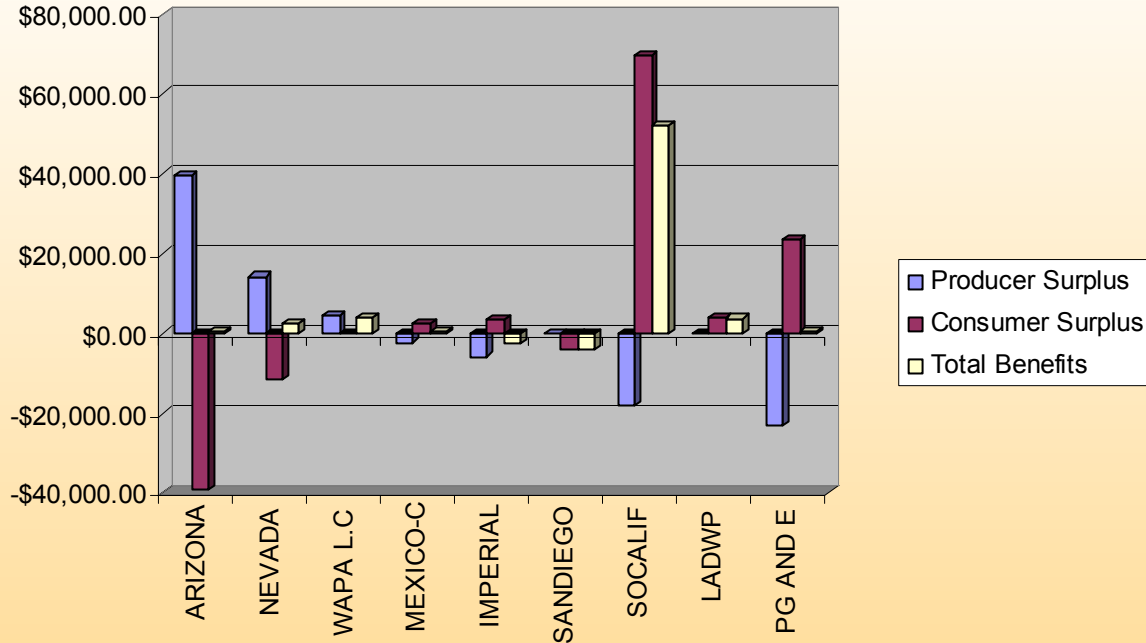




# CALIFORNIA ISO

California Independent System Operator

## Incremental Benefits Due to PVD Series Cap Upgrade



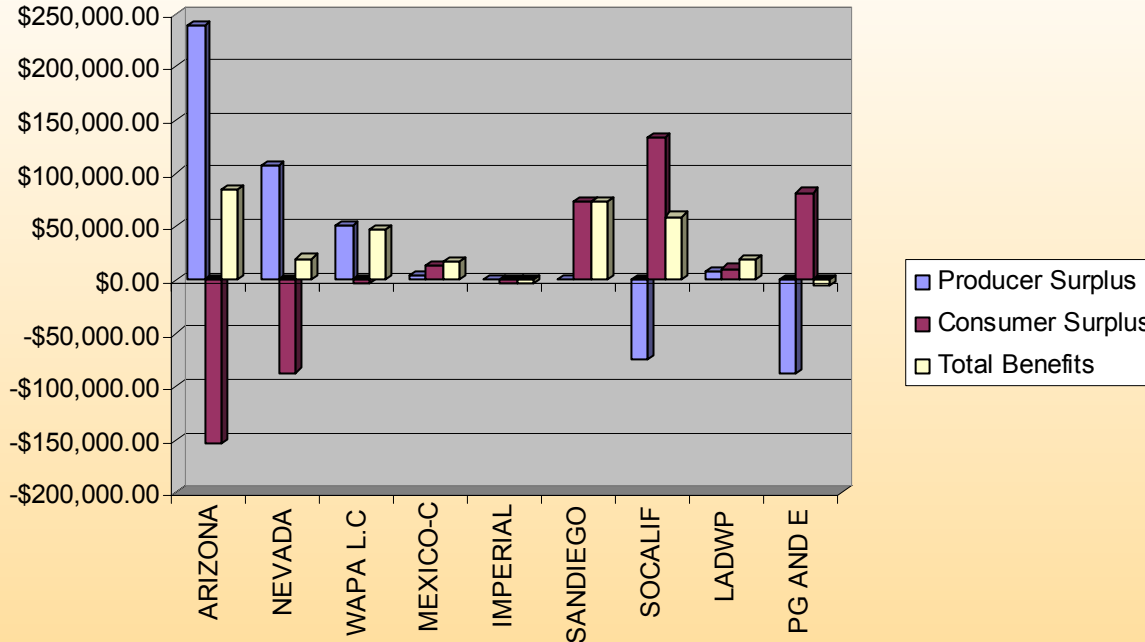
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$39,621.72	\$14,276.80	\$4,332.99	-\$2,250.80	-\$5,806.20	\$76.40	-\$17,947.40	-\$279.39	-\$23,095.88	-\$42,378.34	-\$40,966.89
CS	-\$39,212.00	-\$11,704.00	-\$303.00	\$2,652.00	\$3,479.00	-\$4,124.00	\$69,784.00	\$4,009.00	\$23,583.00	\$92,991.00	\$89,243.00
TB	\$409.72	\$2,572.80	\$4,029.99	\$401.20	-\$2,327.20	-\$4,047.60	\$51,836.60	\$3,729.61	\$487.12	\$50,612.66	\$48,276.11



# CALIFORNIA ISO

California Independent System Operator

## Accumulative Benefits Up to PVD Series Cap Upgrade



	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$238,392.76	\$106,970.52	\$51,055.50	\$4,101.12	\$180.70	\$480.20	-\$73,921.82	\$7,775.70	-\$86,897.99	\$230,258.95	-\$160,339.60
CS	-\$153,019.00	-\$86,608.00	-\$3,537.00	\$13,867.00	-\$3,786.00	\$73,532.00	\$133,671.00	\$10,897.00	\$82,299.00	\$80,593.00	\$289,502.00
TB	\$85,373.76	\$20,362.52	\$47,518.50	\$17,968.12	-\$3,605.30	\$74,012.20	\$59,749.18	\$18,672.70	-\$4,598.99	\$310,851.95	\$129,162.40



# Case 6b: Second PVD

WOR - PV to Devers



EOR - HASSYAMP- N.GILA



WOR - N.GILA - IMPRLVLY



Imp.Valley to Miguel 1



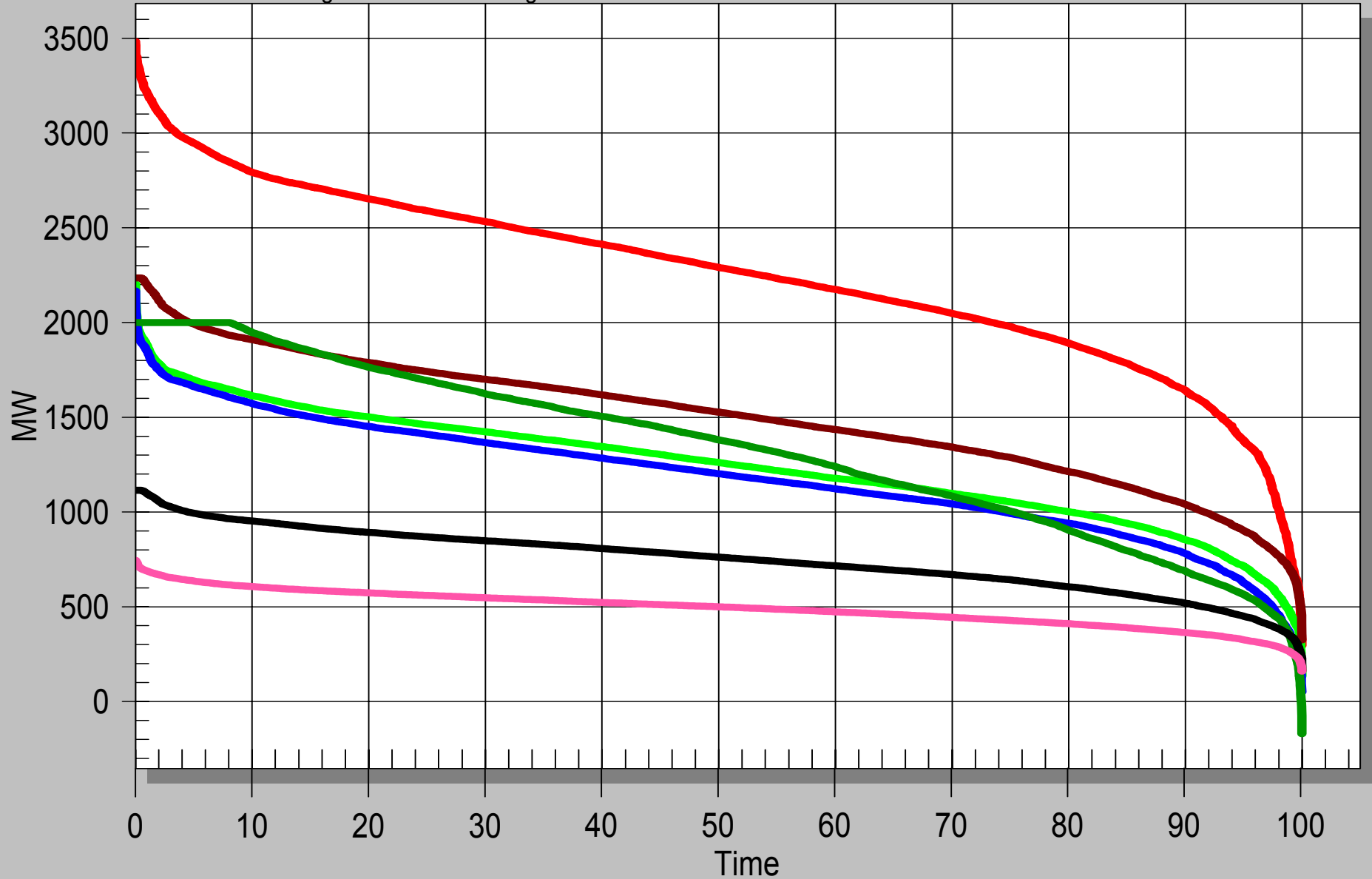
North of Miguel



Miguel Bank No. 1




Devers Bank

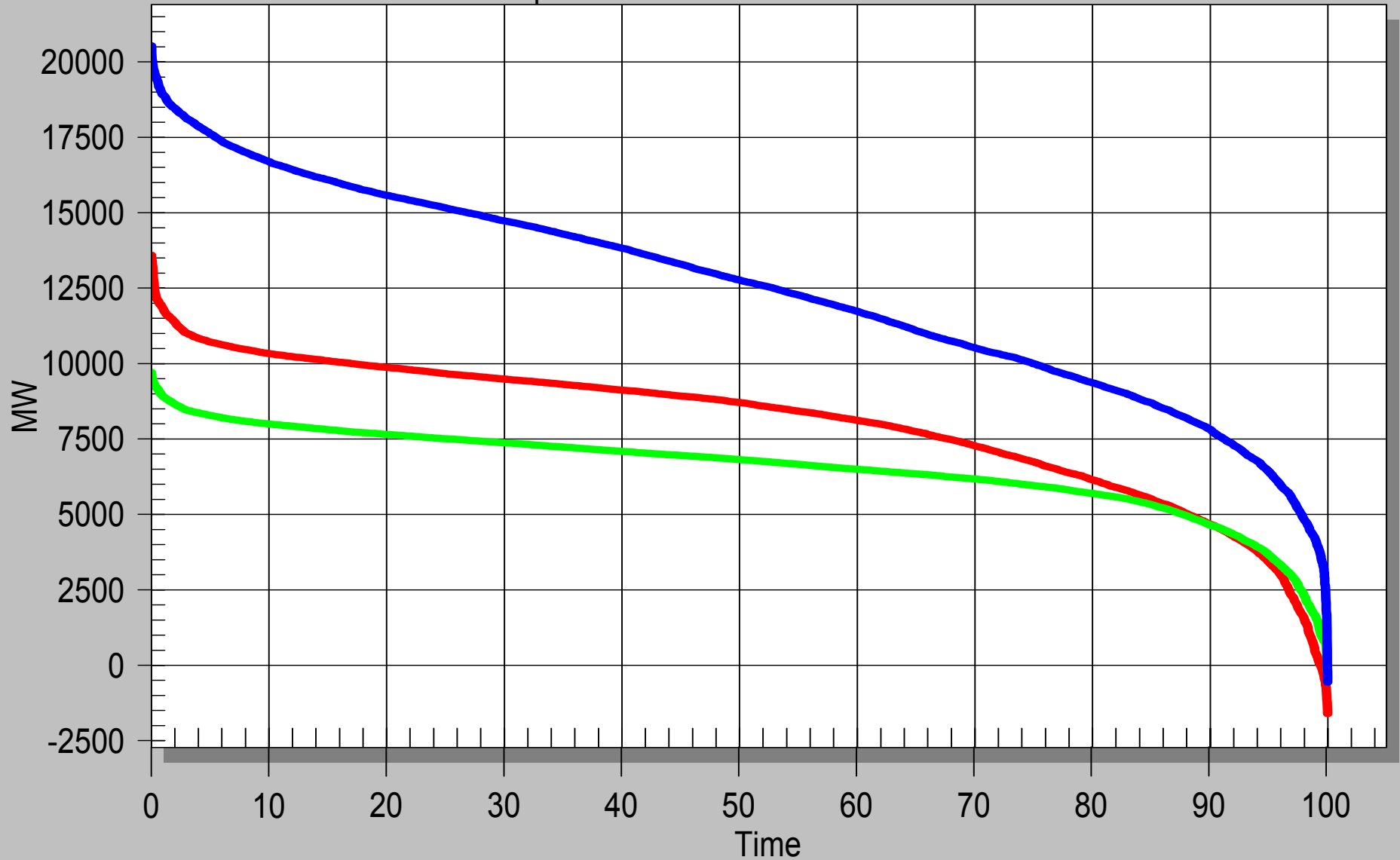


# Case 6b: Second PVD

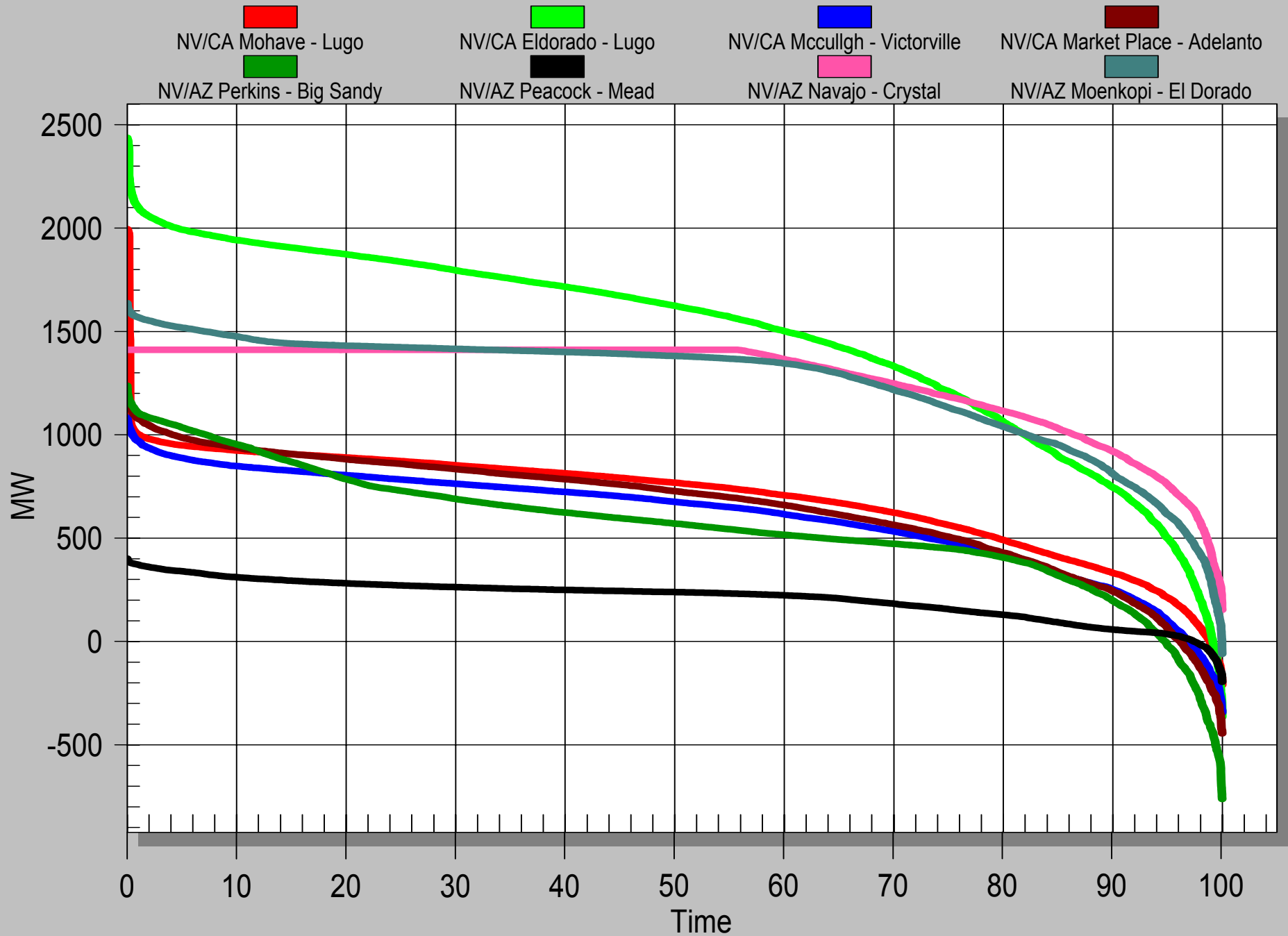
 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports

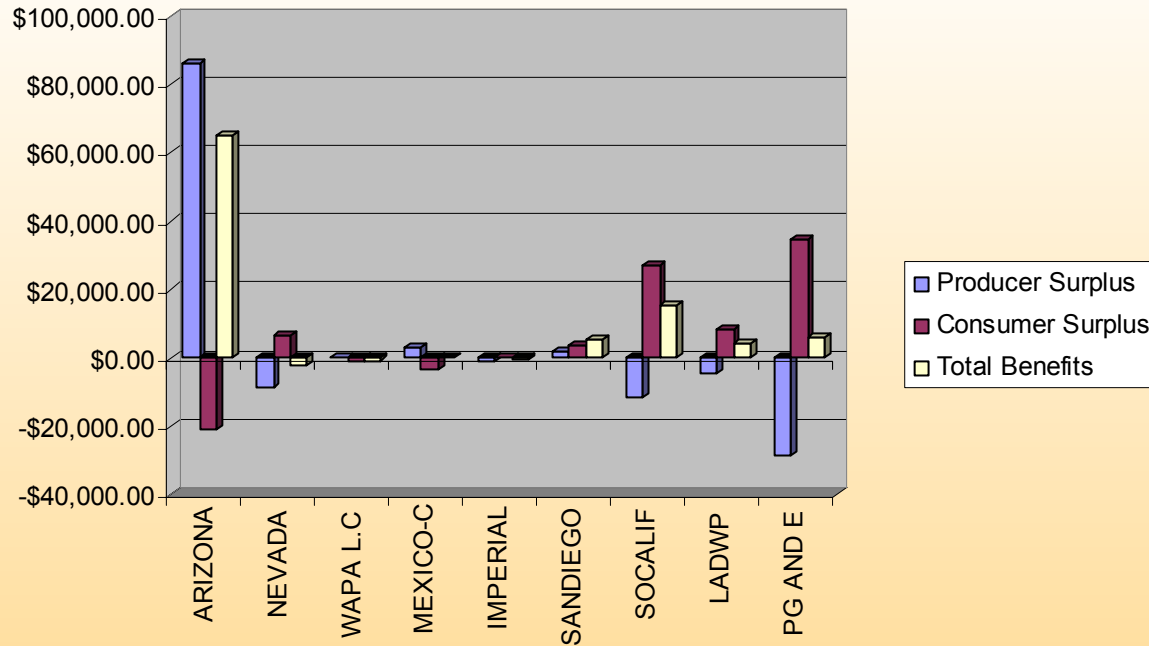


# Case 6b: Second PVD





## Incremental Benefits Due to PVD 2



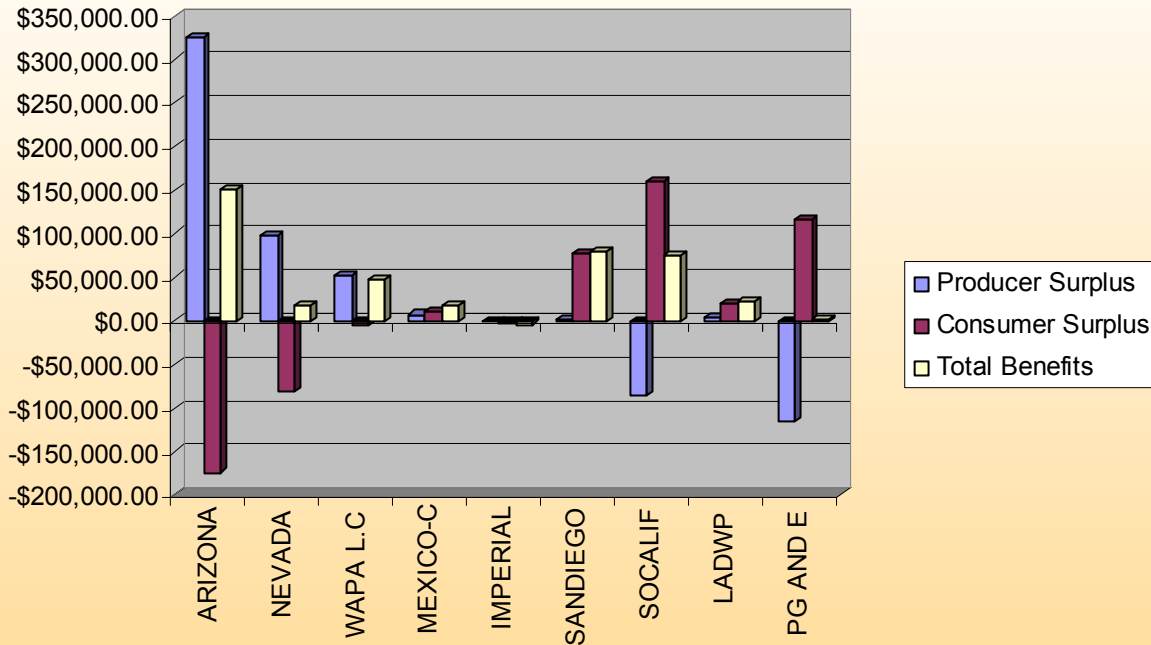
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$86,066.13	-\$8,578.79	\$155.71	\$3,076.88	-\$720.40	\$1,909.19	-\$11,552.90	-\$4,281.93	-\$28,561.62	\$18,952.57	-\$38,205.33
CS	-\$21,028.00	\$6,545.00	-\$816.00	-\$3,126.00	\$129.00	\$3,540.00	\$26,877.00	\$8,423.00	\$34,645.00	\$75,588.00	\$65,062.00
TB	\$65,038.13	-\$2,033.79	-\$660.29	-\$49.12	-\$591.40	\$5,449.19	\$15,324.10	\$4,141.07	\$6,083.38	\$94,540.57	\$26,856.67



# CALIFORNIA ISO

California Independent System Operator

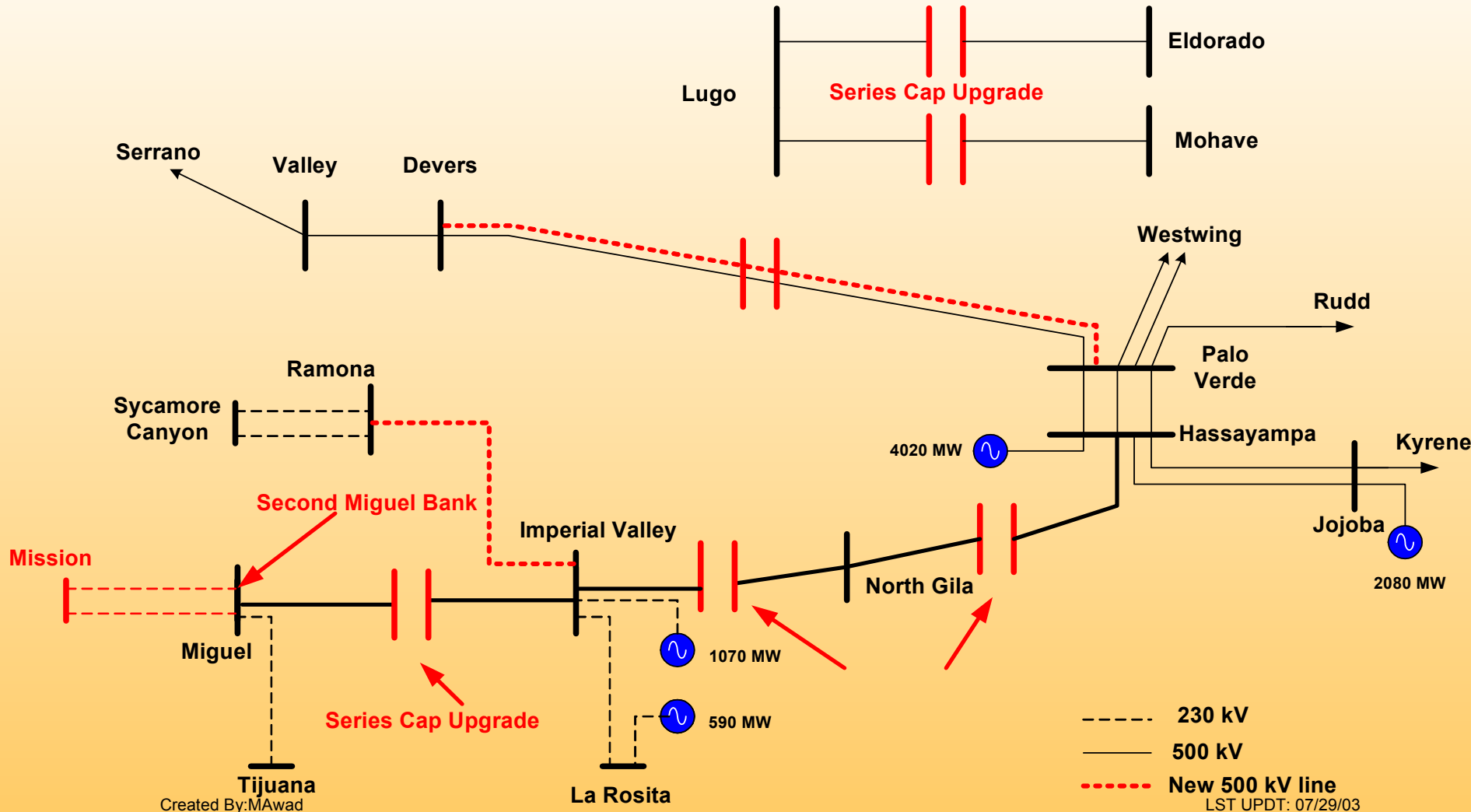
## Accumulative Benefits Up to PVD 2



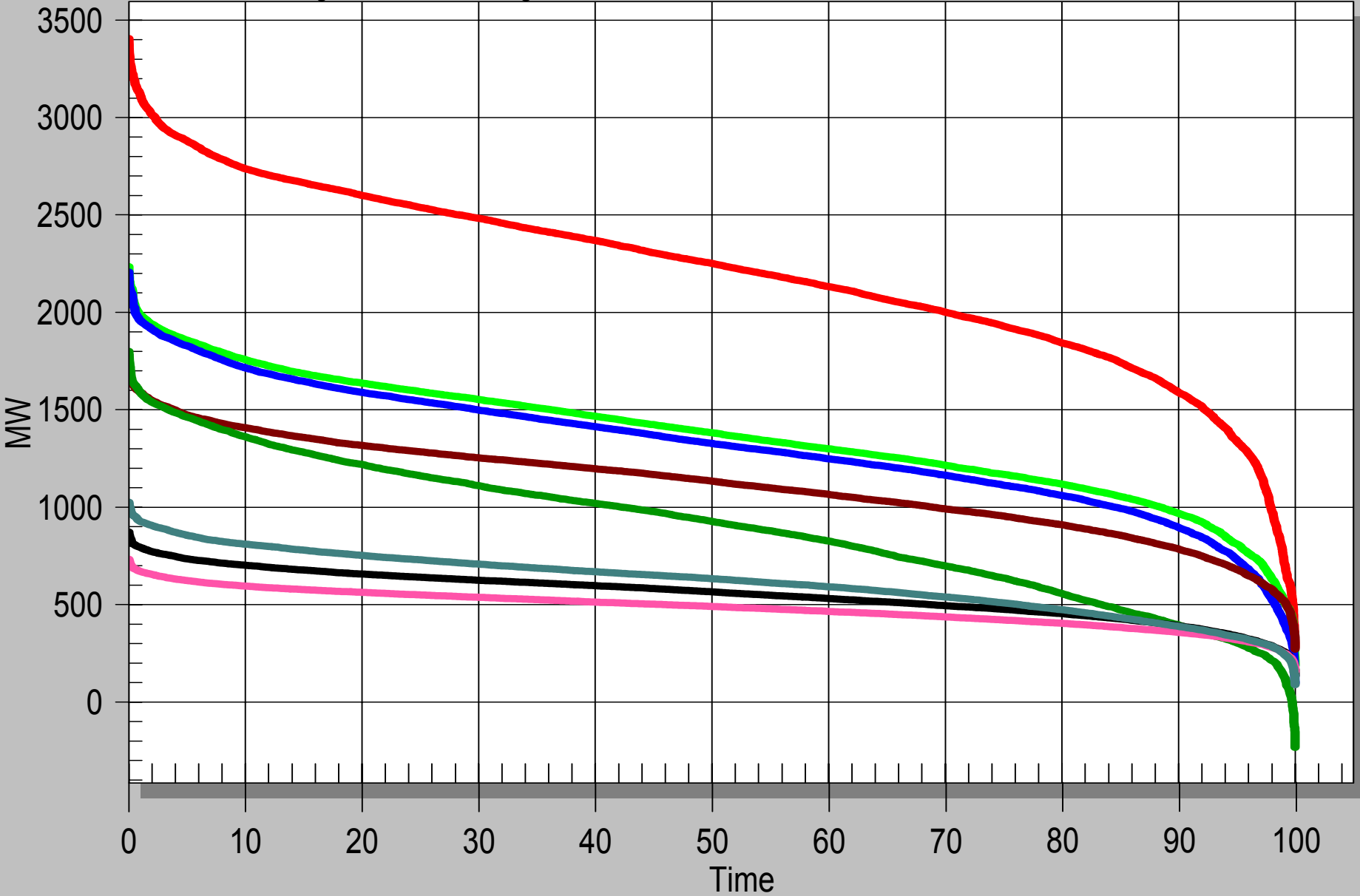
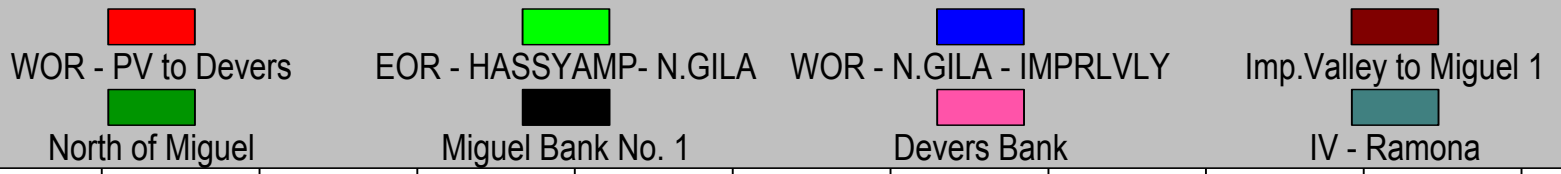
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$324,458.89	\$98,391.73	\$51,211.21	\$7,178.00	-\$539.70	\$2,389.40	-\$85,474.72	\$3,493.77	-\$115,459.61	\$249,211.52	-\$198,544.93
CS	-\$174,047.00	-\$80,063.00	-\$4,353.00	\$10,741.00	-\$3,657.00	\$77,072.00	\$160,548.00	\$19,320.00	\$116,944.00	\$156,181.00	\$354,564.00
TB	\$150,411.89	\$18,328.73	\$46,858.21	\$17,919.00	-\$4,196.70	\$79,461.40	\$75,073.28	\$22,813.77	\$1,484.39	\$405,392.52	\$156,019.07



## Case 7b: Common Upgrade and AC Alternative 1




# Case 7b. AC Option 1

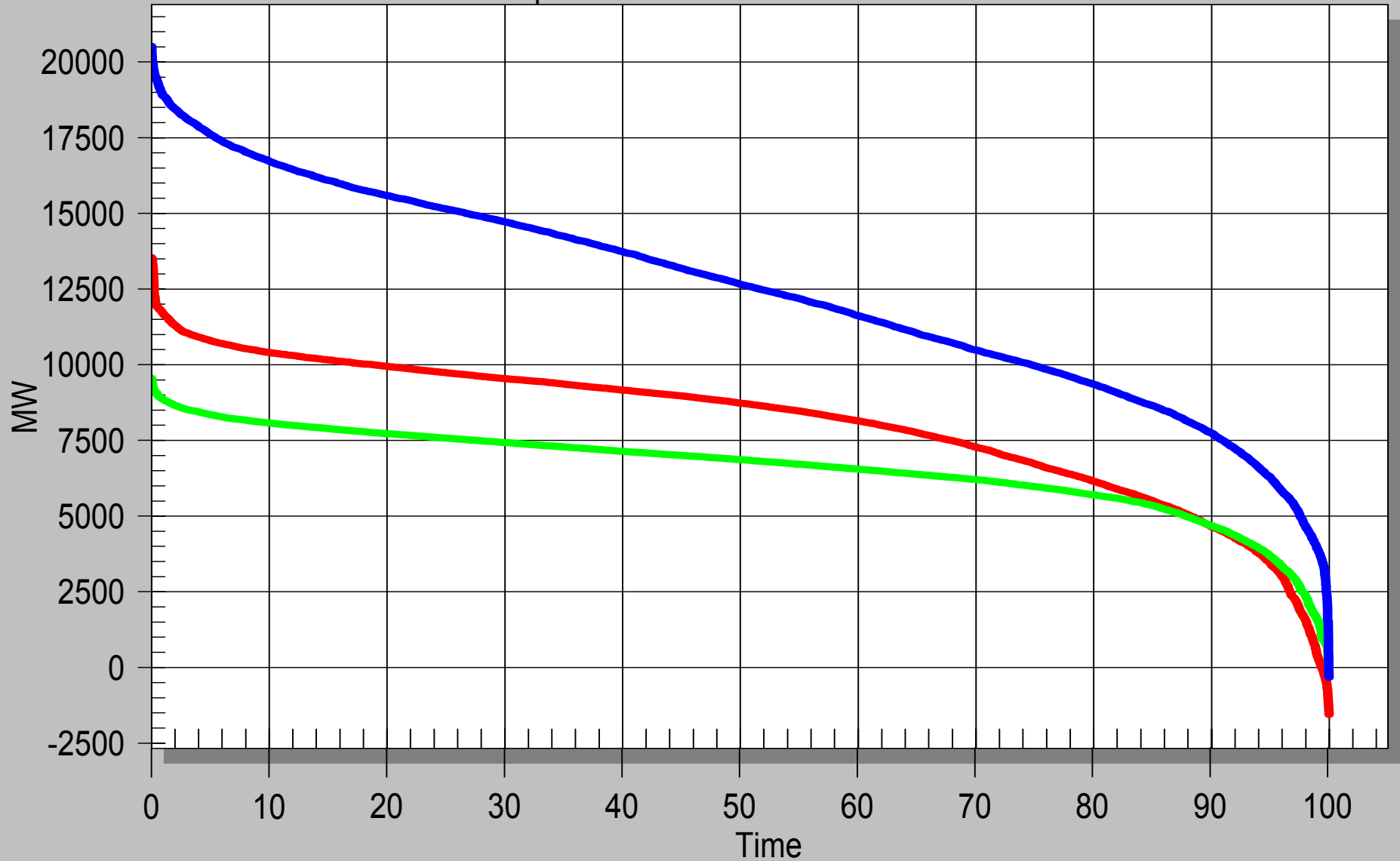


# Case 7b: AC Option 1

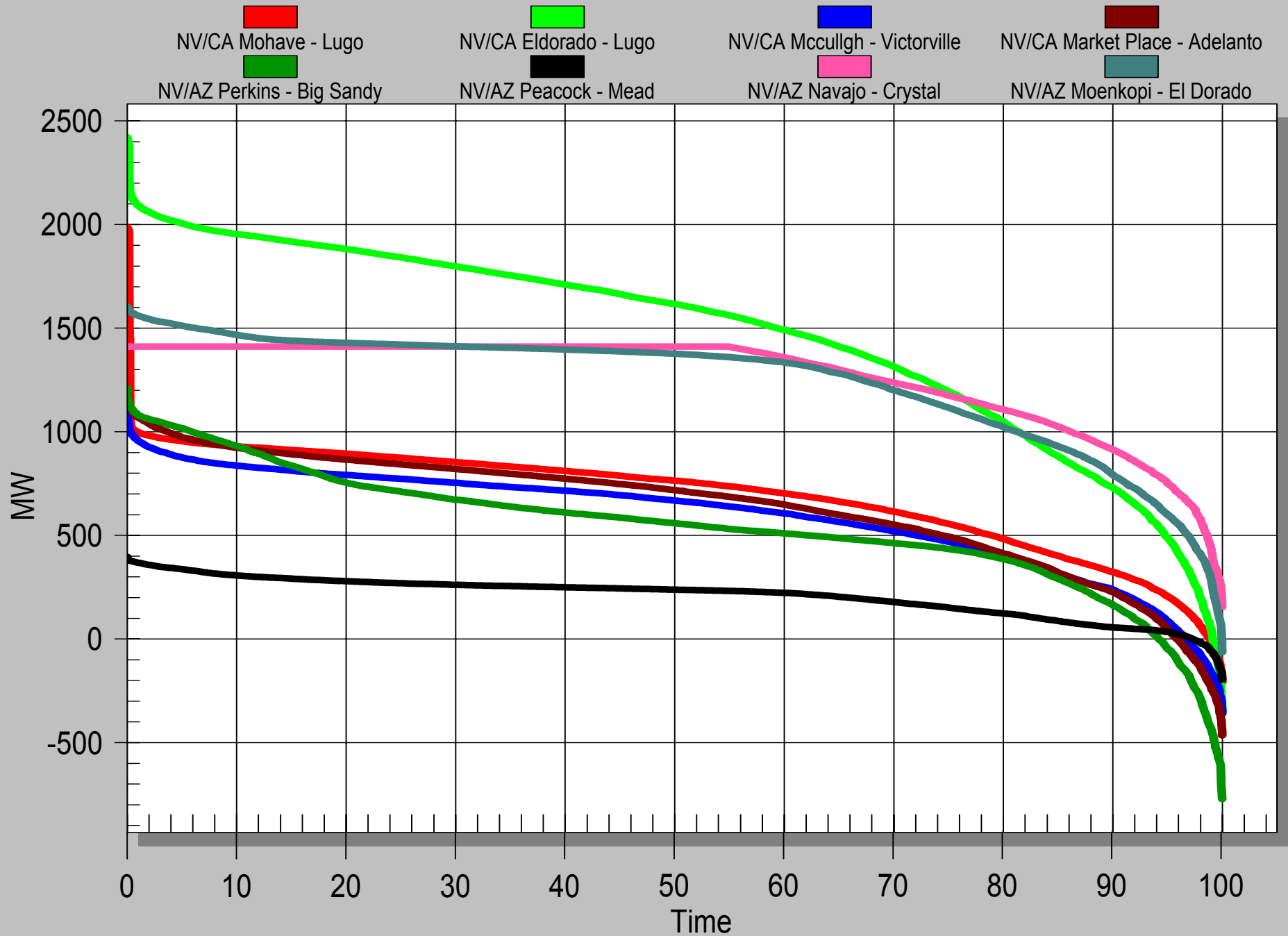
 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports



# Case 7b: AC Option 1

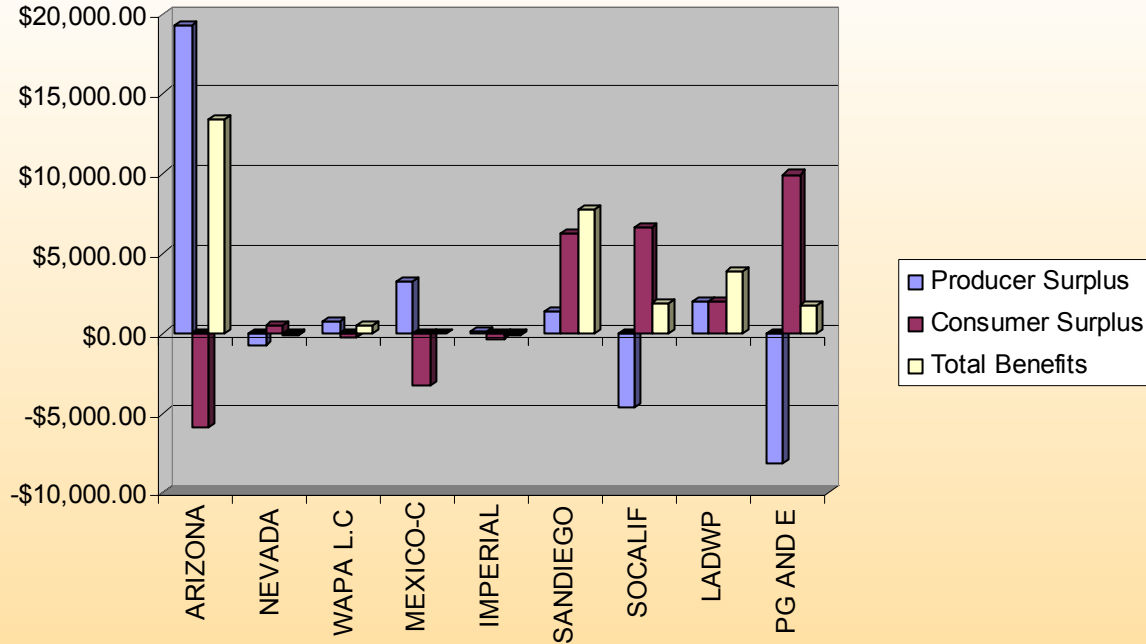




# CALIFORNIA ISO

California Independent System Operator

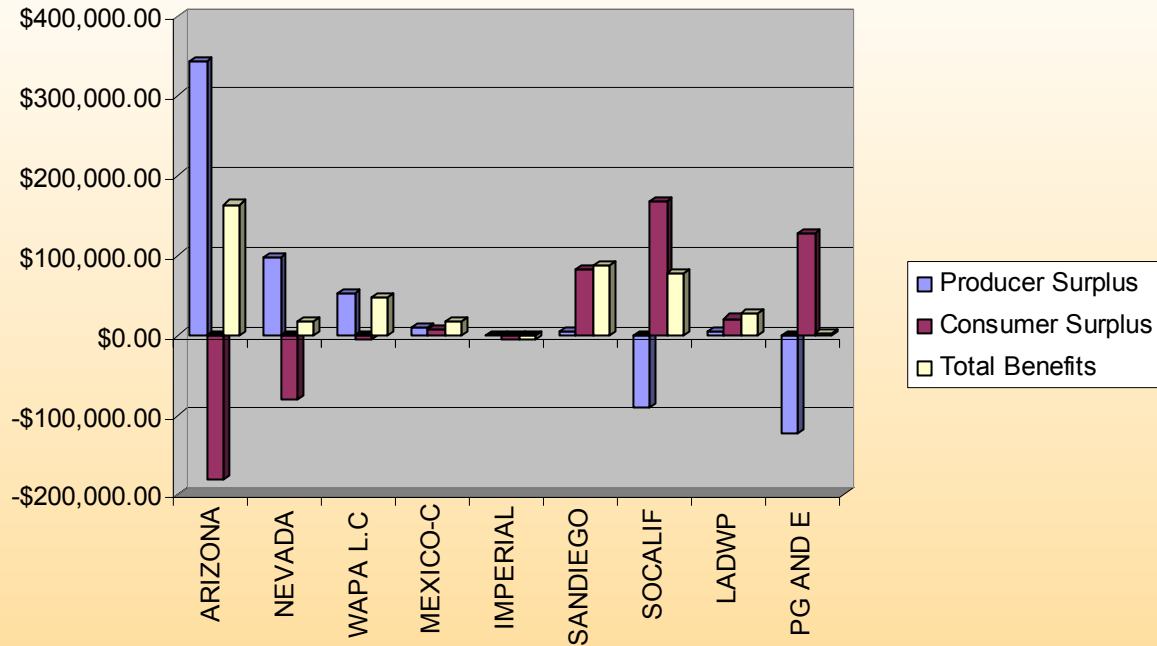
## Incremental Benefits Due to IV - Ramona



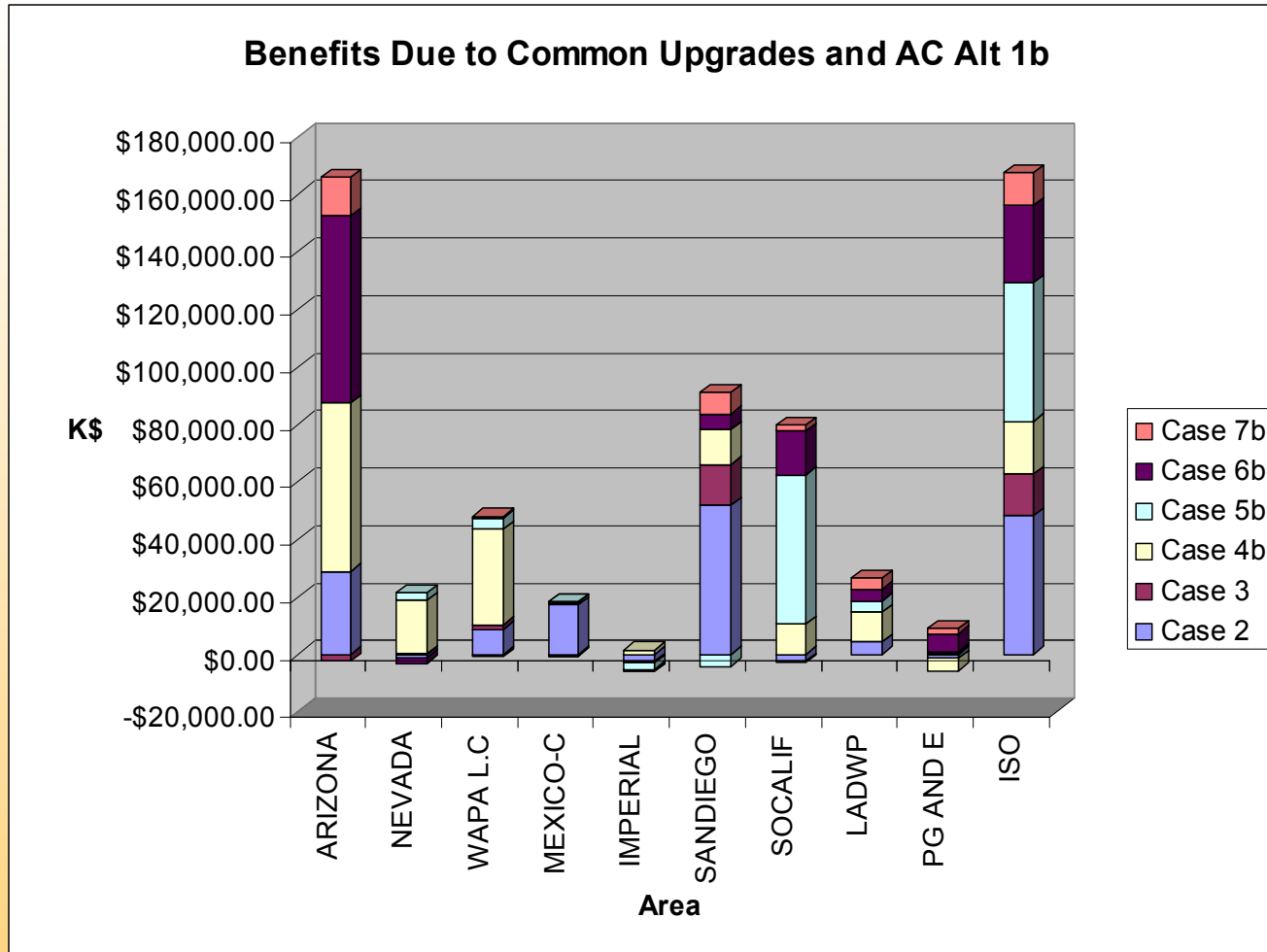
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$19,220.65	-\$704.39	\$759.10	\$3,271.50	\$155.60	\$1,419.90	-\$4,690.39	\$1,970.73	-\$8,188.71	\$2,785.64	-\$11,459.20
CS	-\$5,881.00	\$524.00	-\$240.00	-\$3,294.00	-\$323.00	\$6,289.00	\$6,602.00	\$1,944.00	\$9,946.00	\$30,186.00	\$22,837.00
TB	\$13,339.65	-\$180.39	\$519.10	-\$22.50	-\$167.40	\$7,708.90	\$1,911.61	\$3,914.73	\$1,757.29	\$32,971.64	\$11,377.80



## Total Accumulative Benefits Due to Common Upgrades and AC Alt 1



	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$343,679.54	\$97,687.33	\$51,970.31	\$10,449.51	-\$384.10	\$3,809.30	-\$90,165.11	\$5,464.50	-\$123,648.32	\$251,997.16	-\$210,004.13
CS	-\$179,928.00	-\$79,539.00	-\$4,593.00	\$7,447.00	-\$3,980.00	\$83,361.00	\$167,150.00	\$21,264.00	\$126,890.00	\$186,367.00	\$377,401.00
TB	\$163,751.54	\$18,148.33	\$47,377.31	\$17,896.51	-\$4,364.10	\$87,170.30	\$76,984.89	\$26,728.50	\$3,241.68	\$438,364.16	\$167,396.87

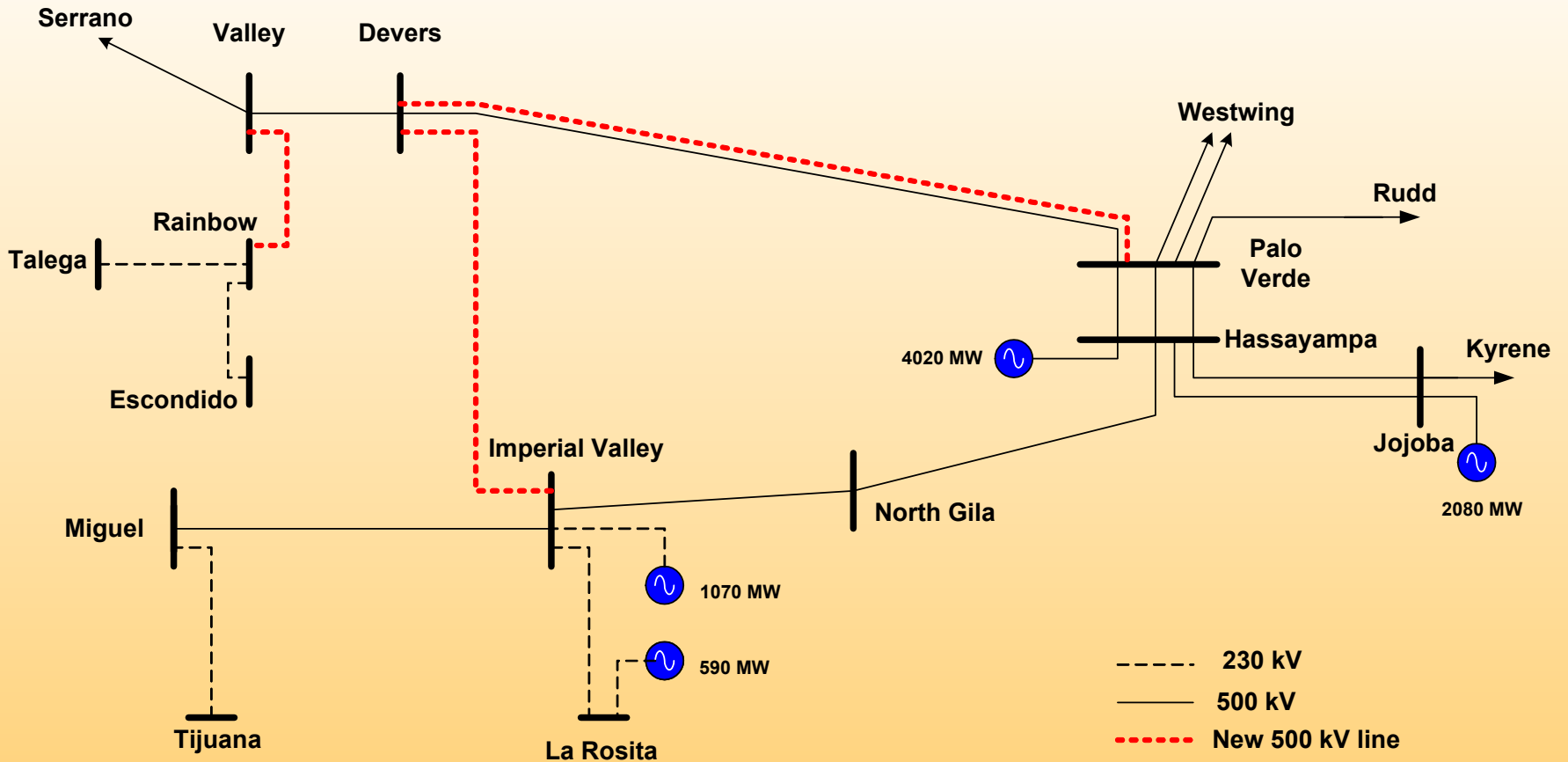


**Case 6b: Common upgrade and PVD 2**

**Case 7b: Case 6b with IV - Ramona**

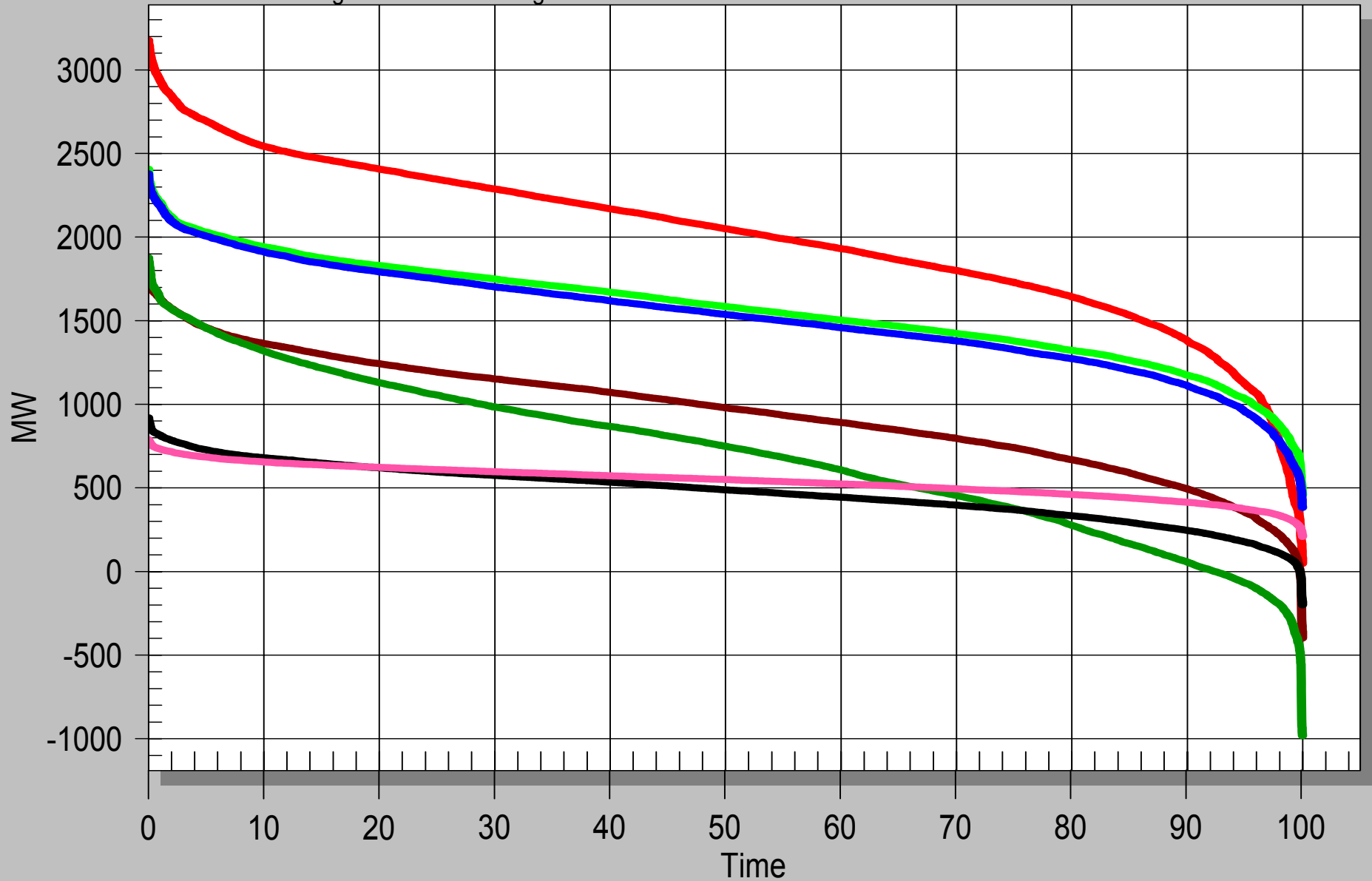


## Case 9b: Common Upgrade and AC Alternative 2



# Case 9b: AC Option 2 With Phase Shifters

WOR - PV to Devers (Red)  
EOR - HASSYAMP- N.GILA (Light Green)  
WOR - N.GILA - IMPRLVLY (Blue)  
Imp.Valley to Miguel 1 (Dark Red)  
North of Miguel (Green)  
Miguel Bank No. 1 (Black)  
Devers Bank (Pink)

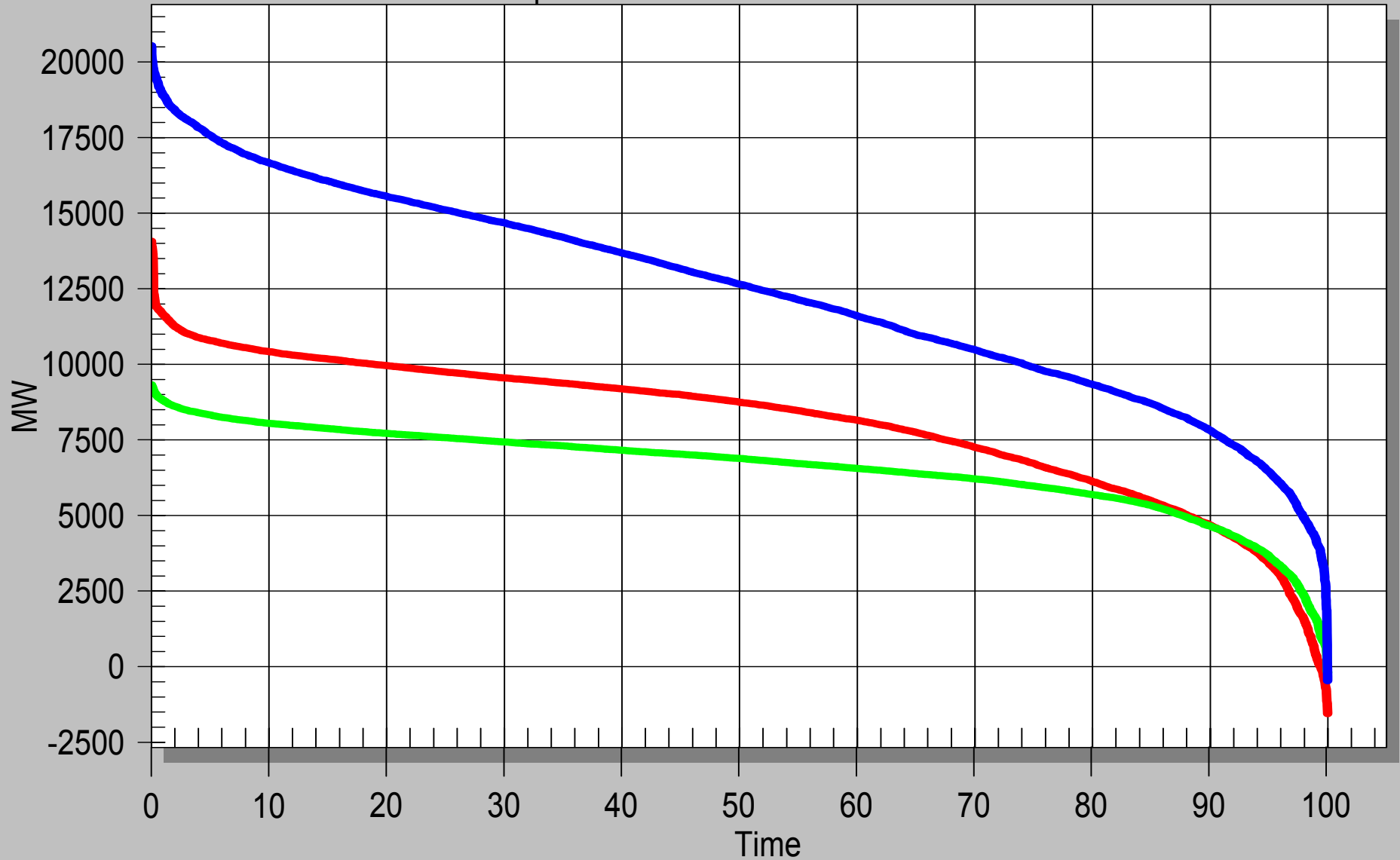


# Case 9b: AC Option 2 With Phase Shifters

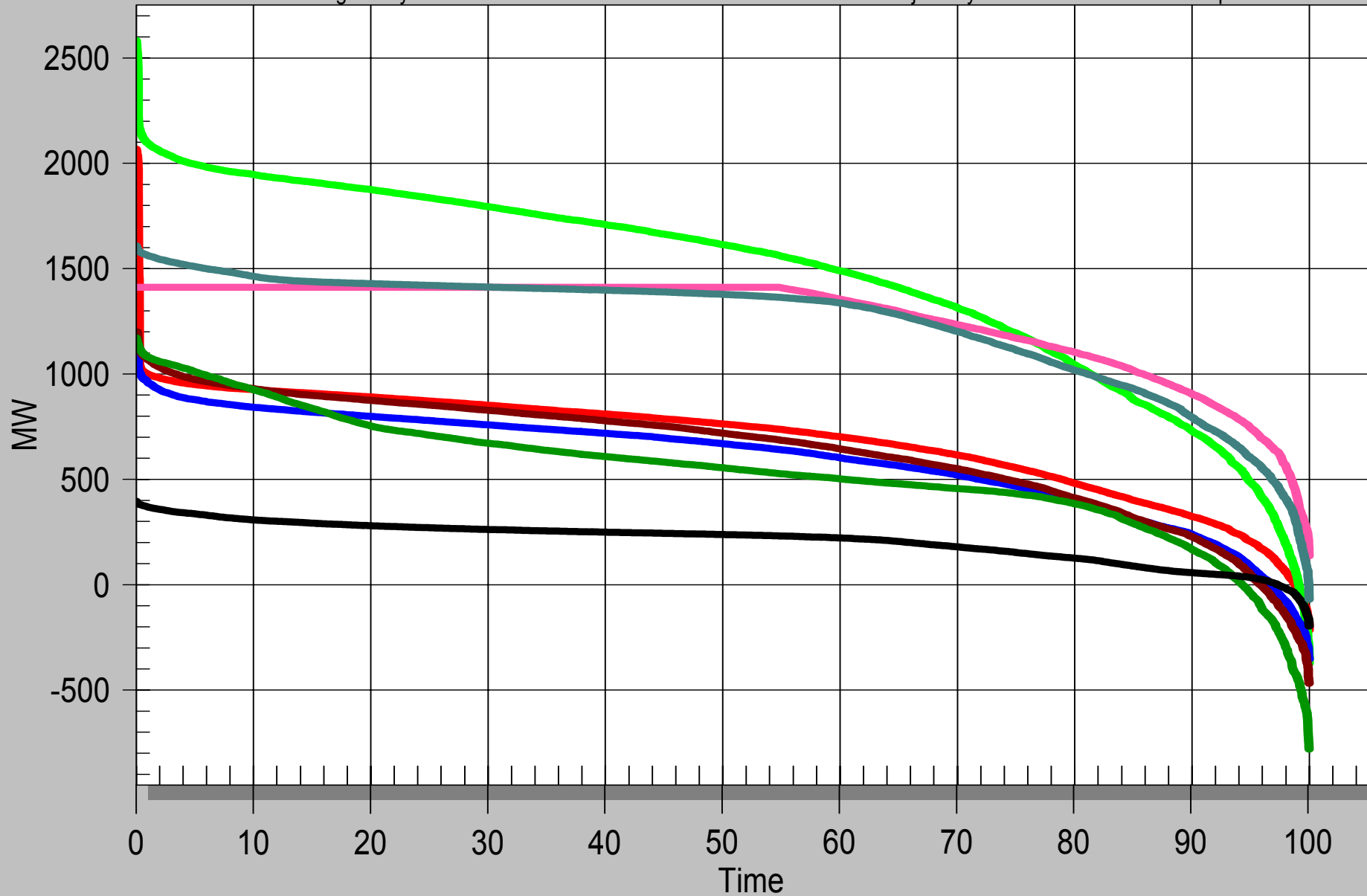
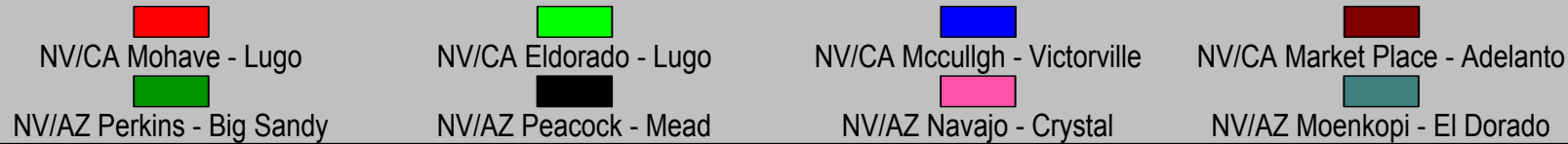
 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports

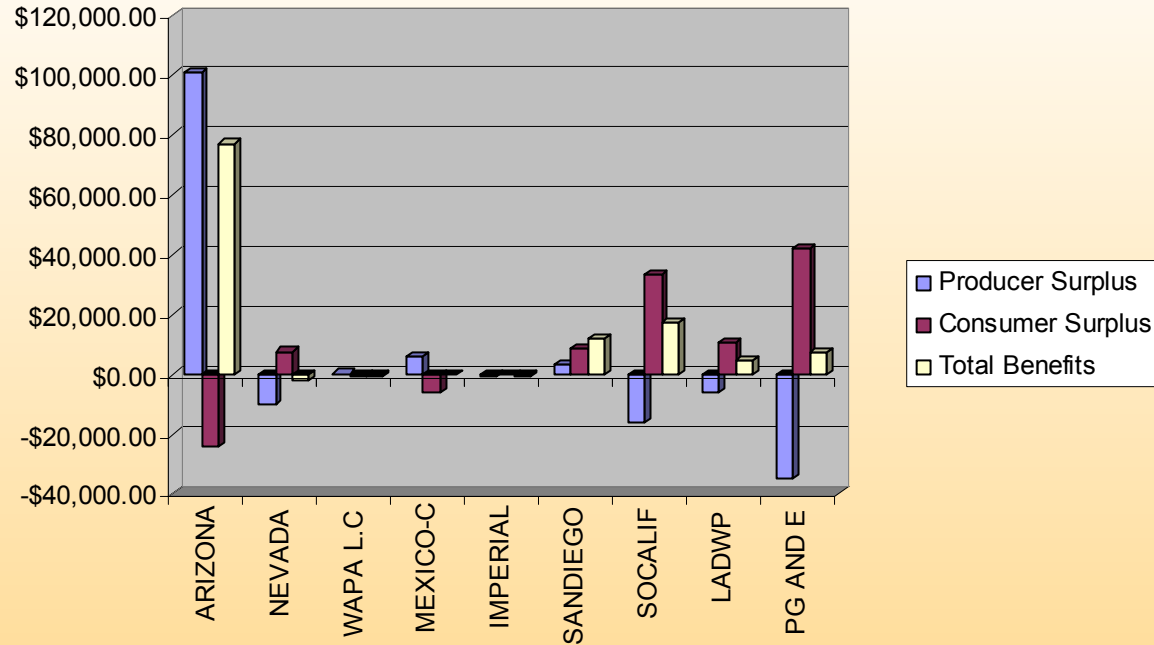


# Case 9b: AC Option 2 With Phase Shifters





## Incremental Benefits Due to AC Alt 2



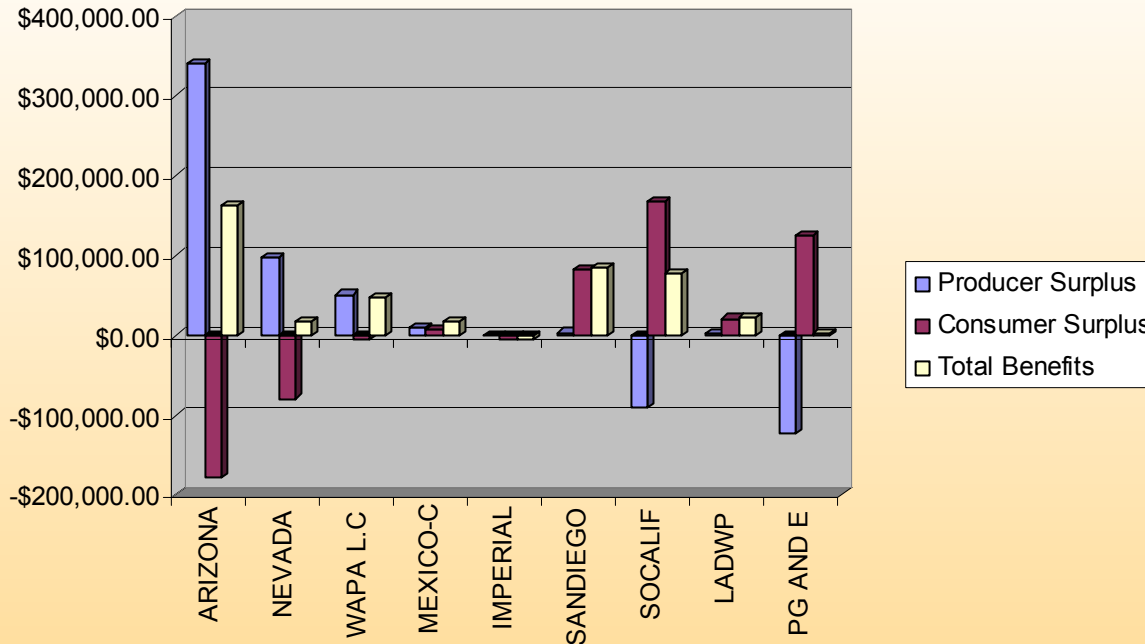
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$100,989.38	-\$9,890.12	\$279.40	\$5,965.68	-\$653.10	\$3,060.89	-\$15,789.22	-\$5,792.59	-\$34,937.04	\$14,544.49	-\$47,665.36
CS	-\$23,962.00	\$7,657.00	-\$943.00	-\$6,235.00	-\$66.00	\$8,690.00	\$33,044.00	\$10,383.00	\$42,135.00	\$100,281.00	\$83,869.00
TB	\$77,027.38	-\$2,233.12	-\$663.60	-\$269.32	-\$719.10	\$11,750.89	\$17,254.78	\$4,590.41	\$7,197.96	\$114,825.49	\$36,203.64



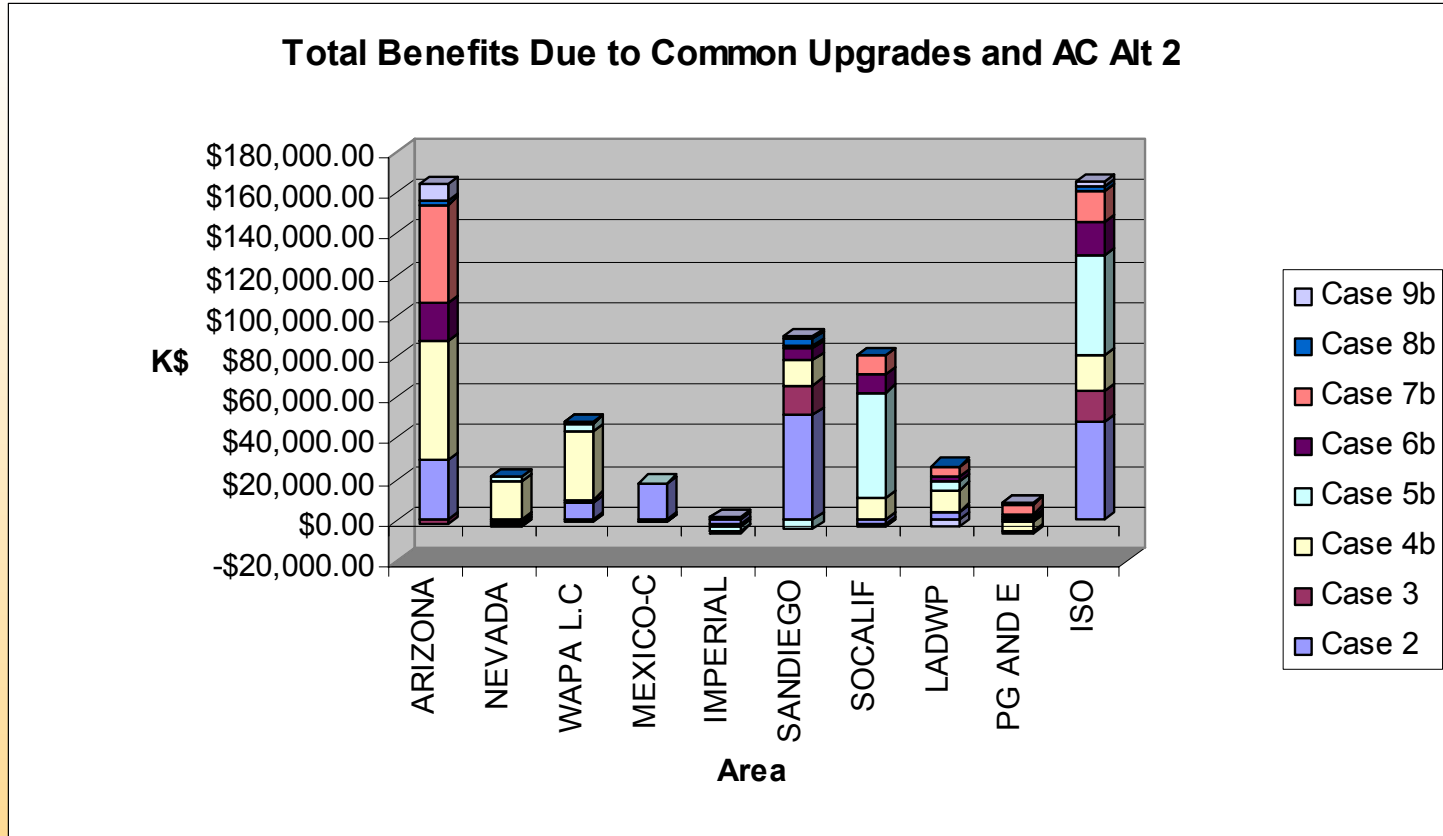
# CALIFORNIA ISO

California Independent System Operator

## Total Accumulative Benefits Due Common Upgrades and AC Alt 2



	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$339,382.14	\$97,080.41	\$51,334.90	\$10,066.79	-\$472.40	\$3,541.10	-\$89,711.04	\$1,983.11	-\$121,835.02	\$244,803.44	-\$208,004.96
CS	-\$176,981.00	-\$78,951.00	-\$4,480.00	\$7,632.00	-\$3,852.00	\$82,222.00	\$166,715.00	\$21,280.00	\$124,434.00	\$180,874.00	\$373,371.00
TB	\$162,401.14	\$18,129.41	\$46,854.90	\$17,698.79	-\$4,324.40	\$85,763.10	\$77,003.96	\$23,263.11	\$2,598.98	\$425,677.44	\$165,366.04



**Case 6b: Common upgrades with IV - Devers**

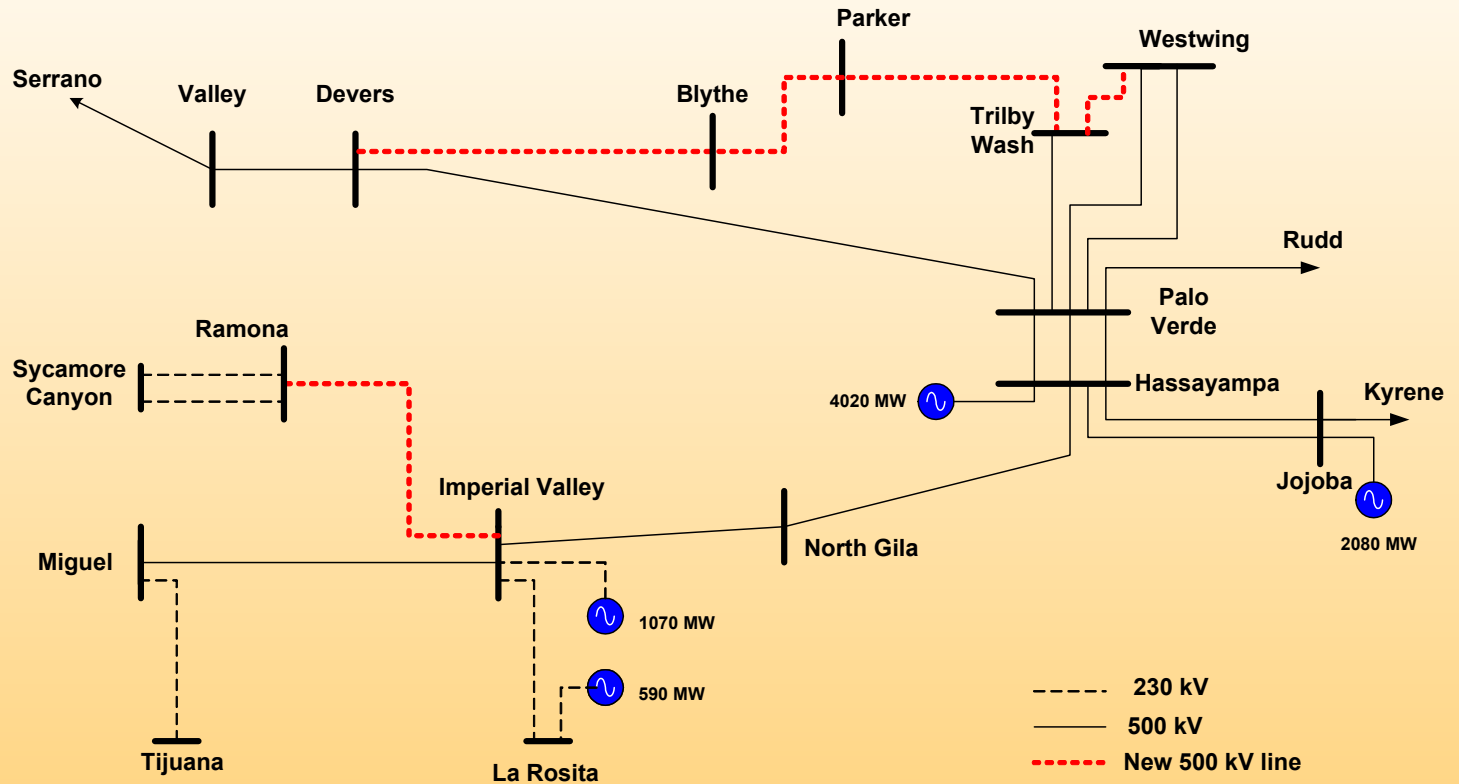
**Case 7b: Case 6b PVD 2**

**Case 8b: Case 7b with Valley – Rainbow**

**Case 9b: Case 8b with two phase shifters**



## Case 7b: Common Upgrade and AC Alternative 3




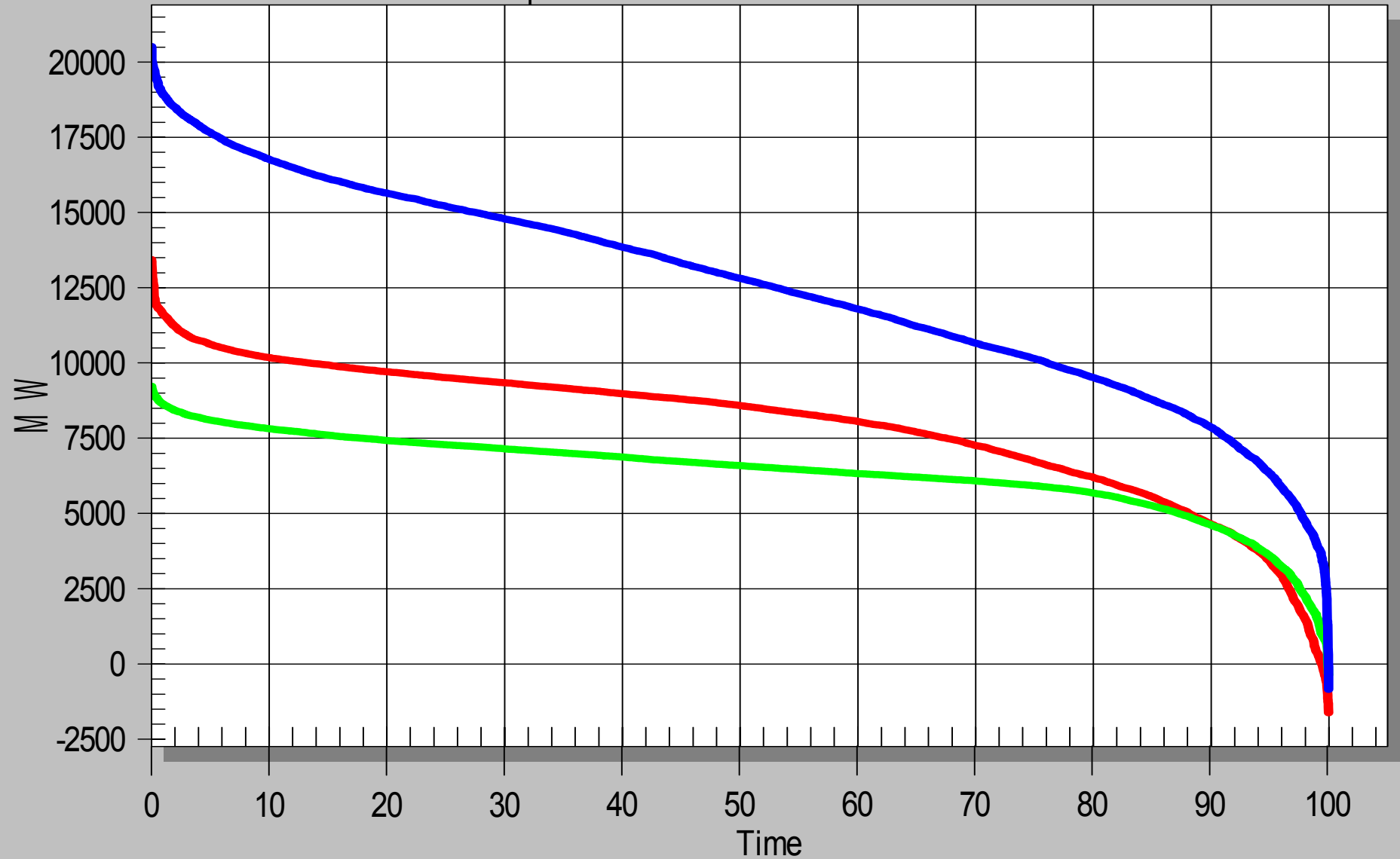


# Case 7b: AC Option 3

 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

 Southern CA Imports



# Case 7b: AC Option 3

NV/CAMohave - Lugo

NV/CAEldorado - Lugo

NV/CAMccullgh - Victorville

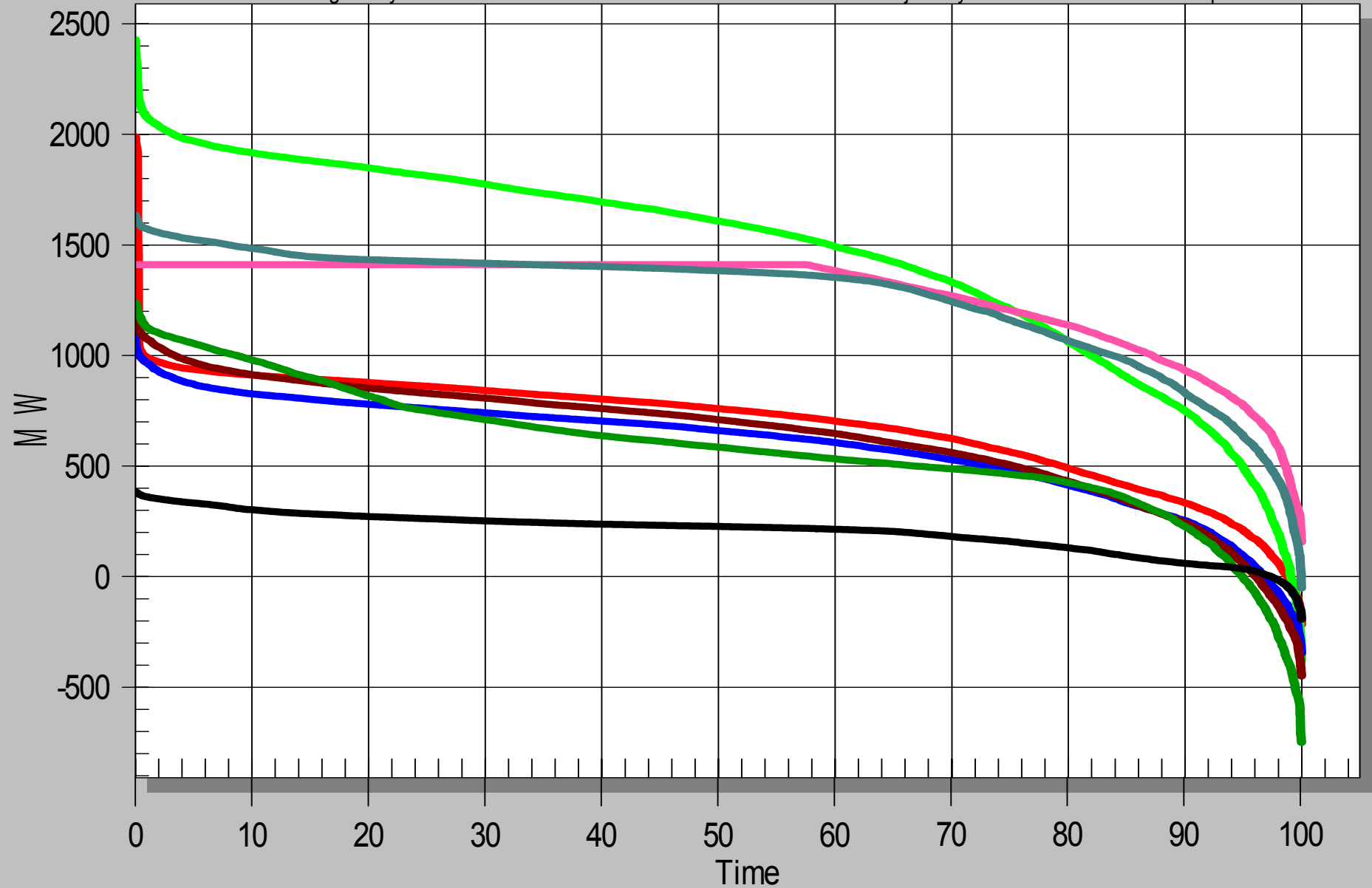
NV/CAMarketPlace - Adelanto

NV/AZ Perkins - Big Sandy

NV/AZ Peacock - Mead

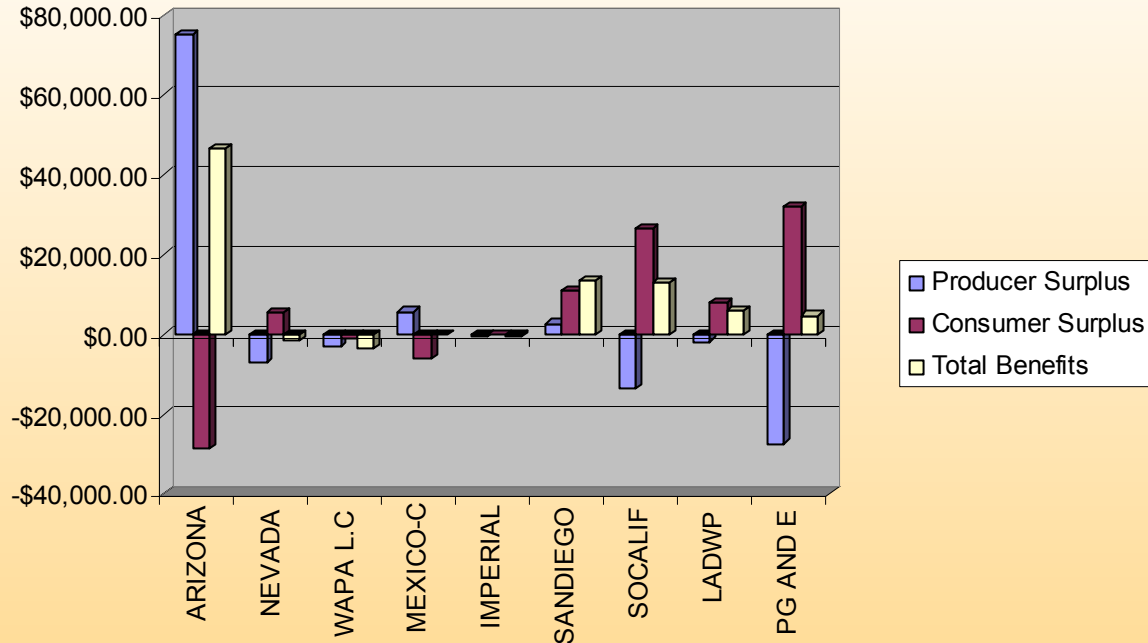
NV/AZ Navajo - Crystal

NV/AZ Moenkopi - El Dorado





## Incremental Benefits Due to AC Alt 3



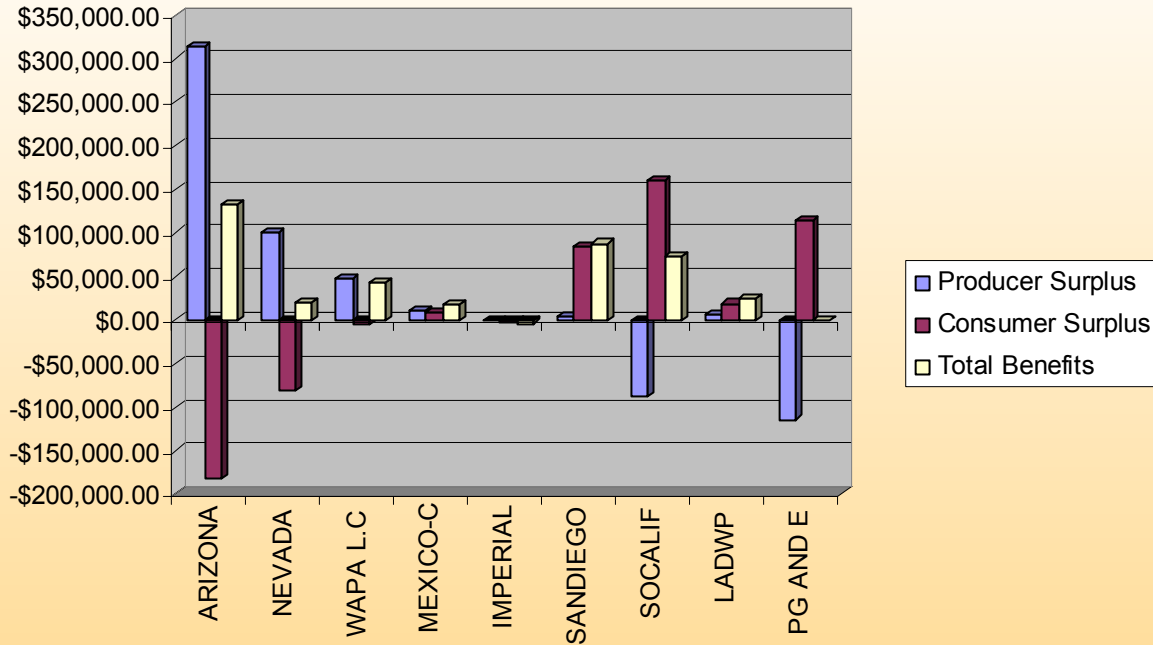
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$75,213.86	-\$7,006.21	-\$2,843.50	\$5,759.79	-\$592.10	\$2,716.20	-\$13,551.70	-\$1,809.50	-\$27,319.40	\$8,522.36	-\$38,154.90
CS	-\$28,491.00	\$5,693.00	-\$901.00	-\$5,876.00	\$159.00	\$10,793.00	\$26,508.00	\$7,903.00	\$32,046.00	\$73,531.00	\$69,347.00
TB	\$46,722.86	-\$1,313.21	-\$3,744.50	-\$116.21	-\$433.10	\$13,509.20	\$12,956.30	\$6,093.50	\$4,726.60	\$82,053.36	\$31,192.10



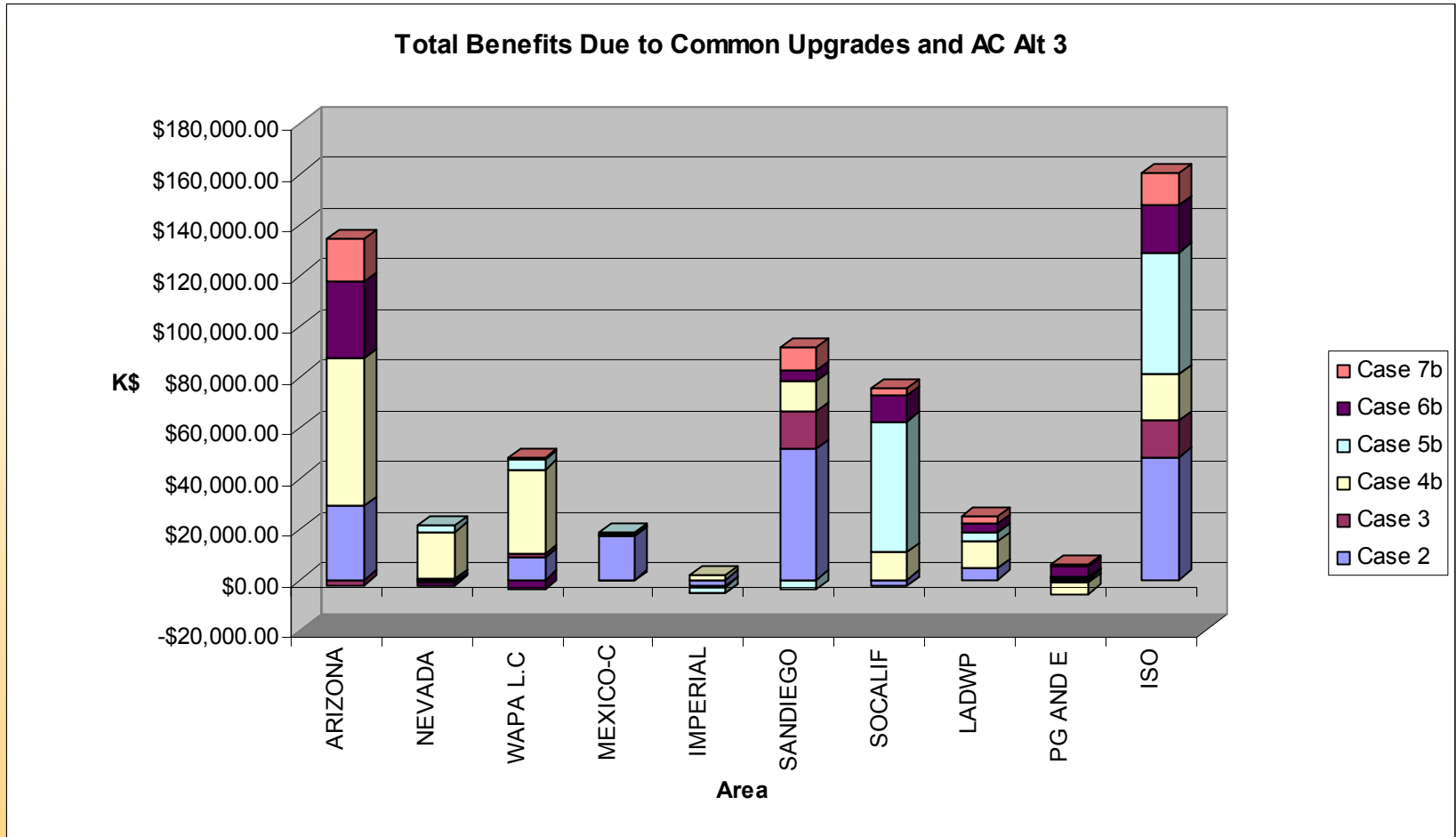
# CALIFORNIA ISO

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## Total Accumulative Benefits Due Common Upgrades and AC Alt 3



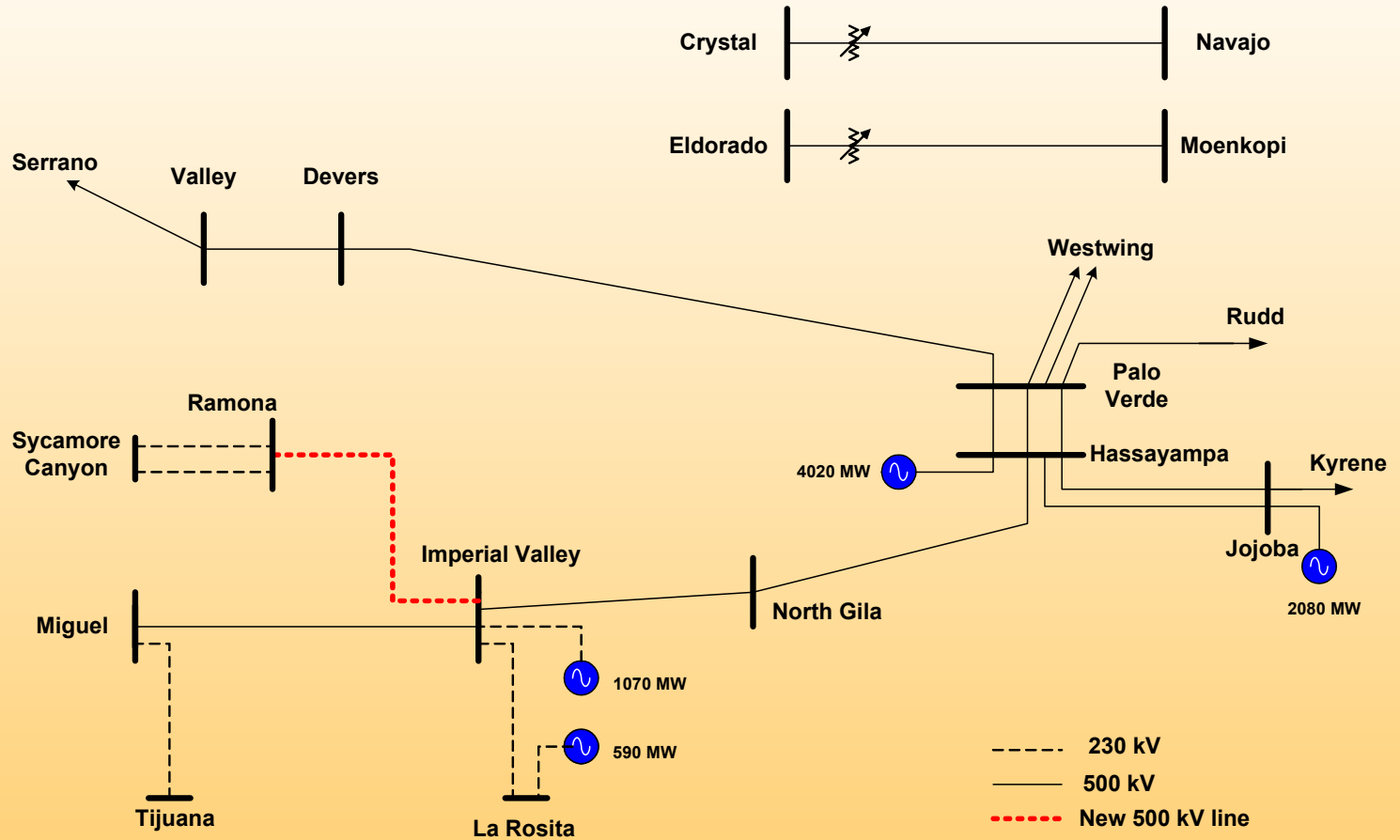
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$313,606.62	\$99,964.31	\$48,212.00	\$9,860.91	-\$411.40	\$3,196.40	-\$87,473.52	\$5,966.20	-\$114,217.39	\$238,781.31	-\$198,494.50
CS	-\$181,510.00	-\$80,915.00	-\$4,438.00	\$7,991.00	-\$3,627.00	\$84,325.00	\$160,179.00	\$18,800.00	\$114,345.00	\$154,124.00	\$358,849.00
TB	\$132,096.62	\$19,049.31	\$43,774.00	\$17,851.91	-\$4,038.40	\$87,521.40	\$72,705.48	\$24,766.20	\$127.61	\$392,905.31	\$160,354.50



**Case 6b: Common upgrades and Trilby Wash – Devers and Trilby Wash - WW**  
**Case 7b: Case 6b with IV - Ramona**




## Case 7b: Common Upgrade and AC Alternative 4



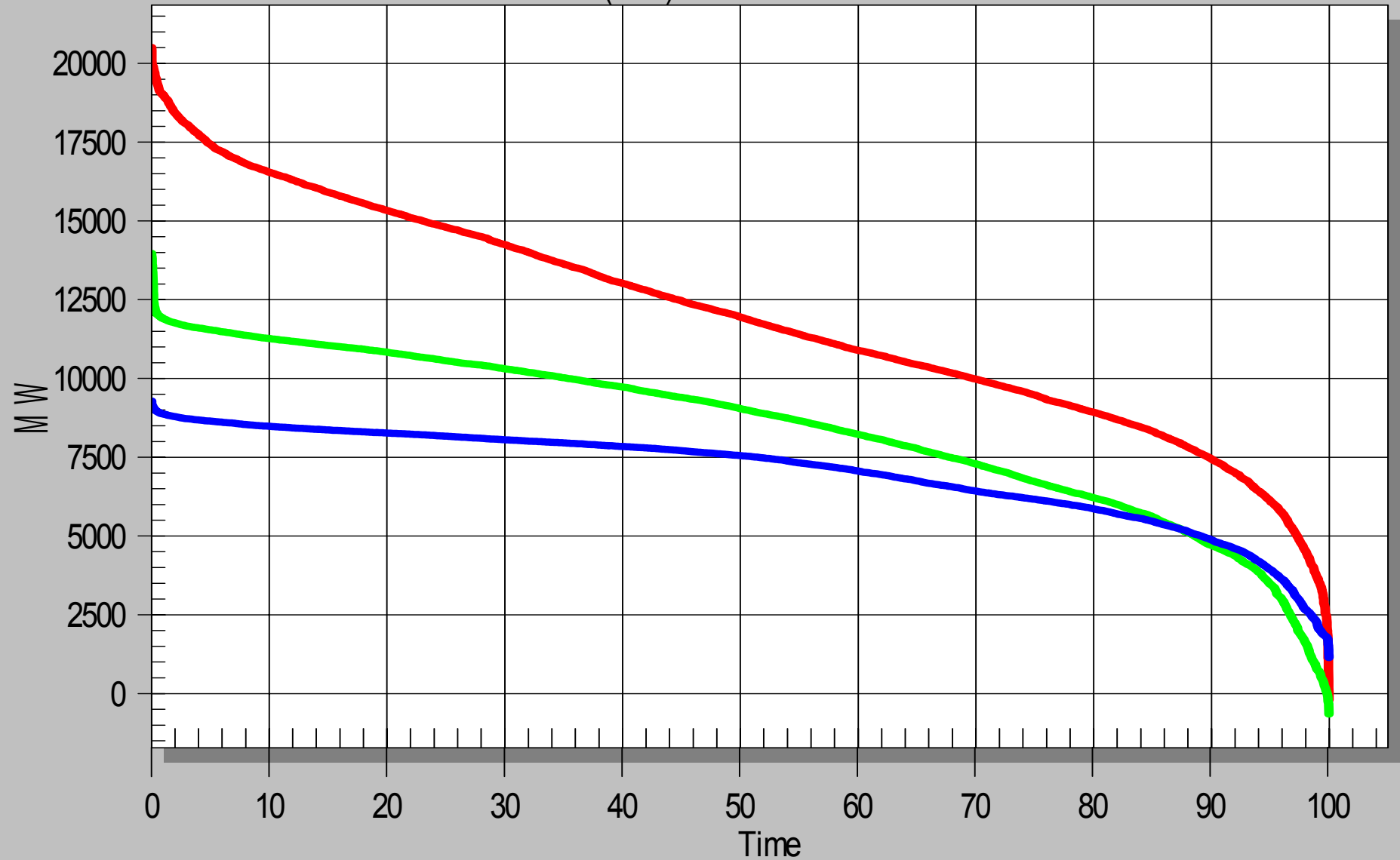


# Case 7b: AC Option 4

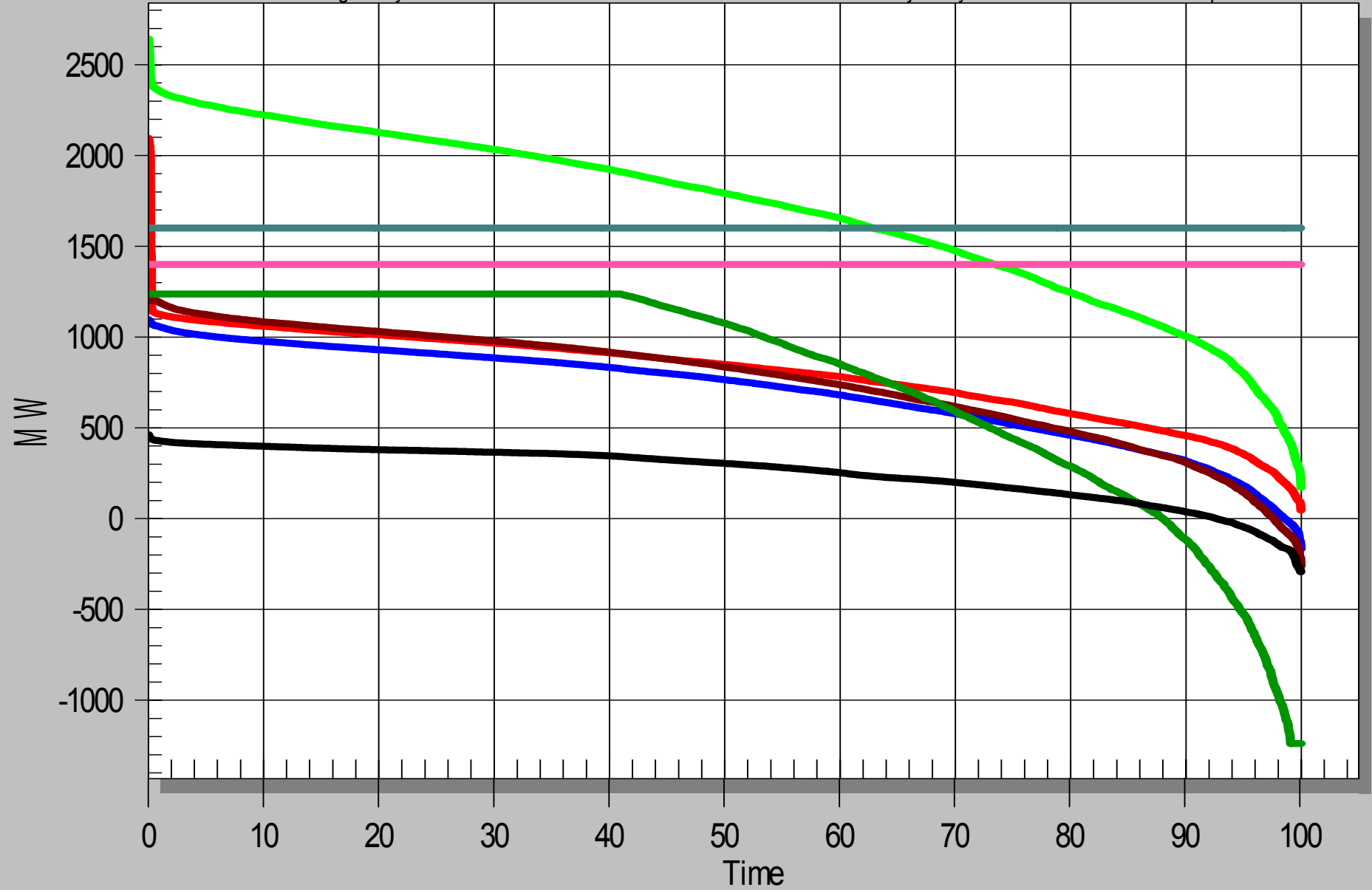
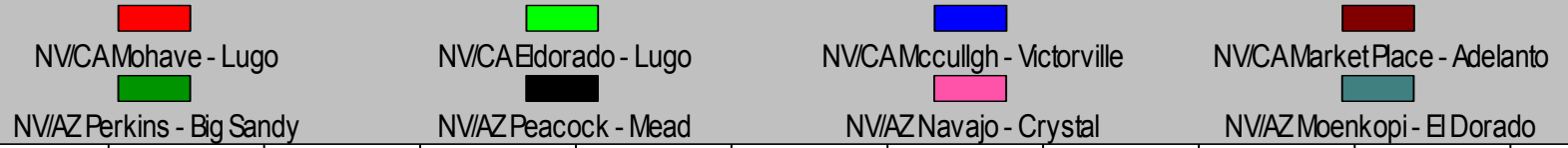
 Southern CA Imports

 WEST OF COLORADO RIVER (WOR)

 EAST OF COLORADO RIVER (EOR)

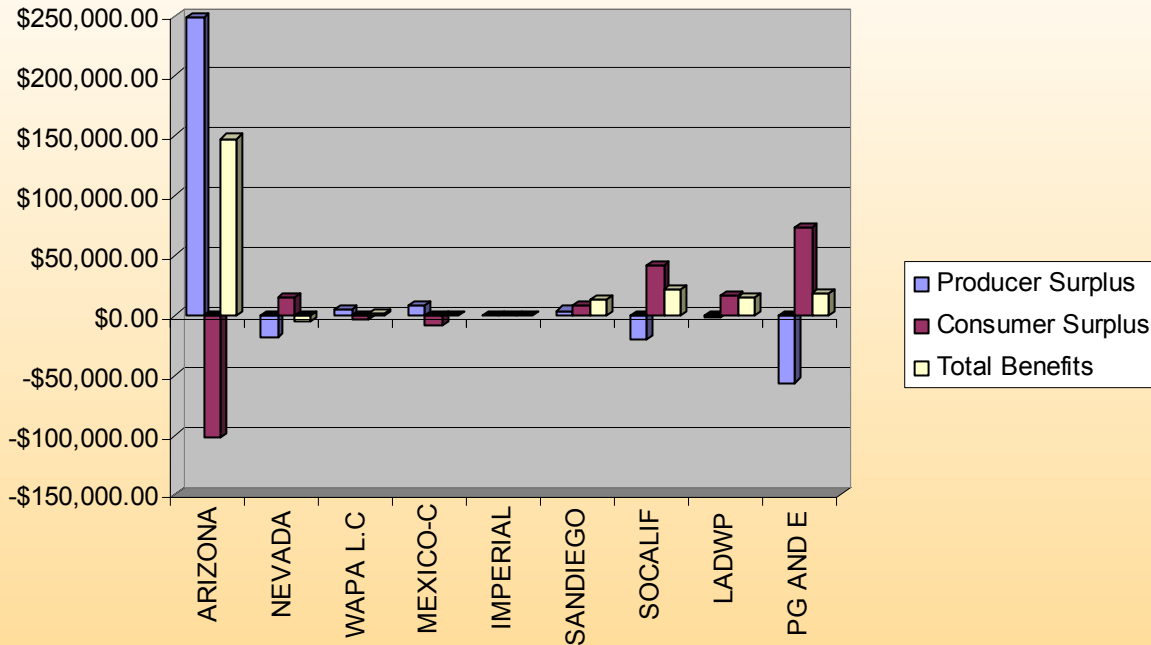


# Case 7b: AC Option 4





## Incremental Benefits Due to AC Alt 4



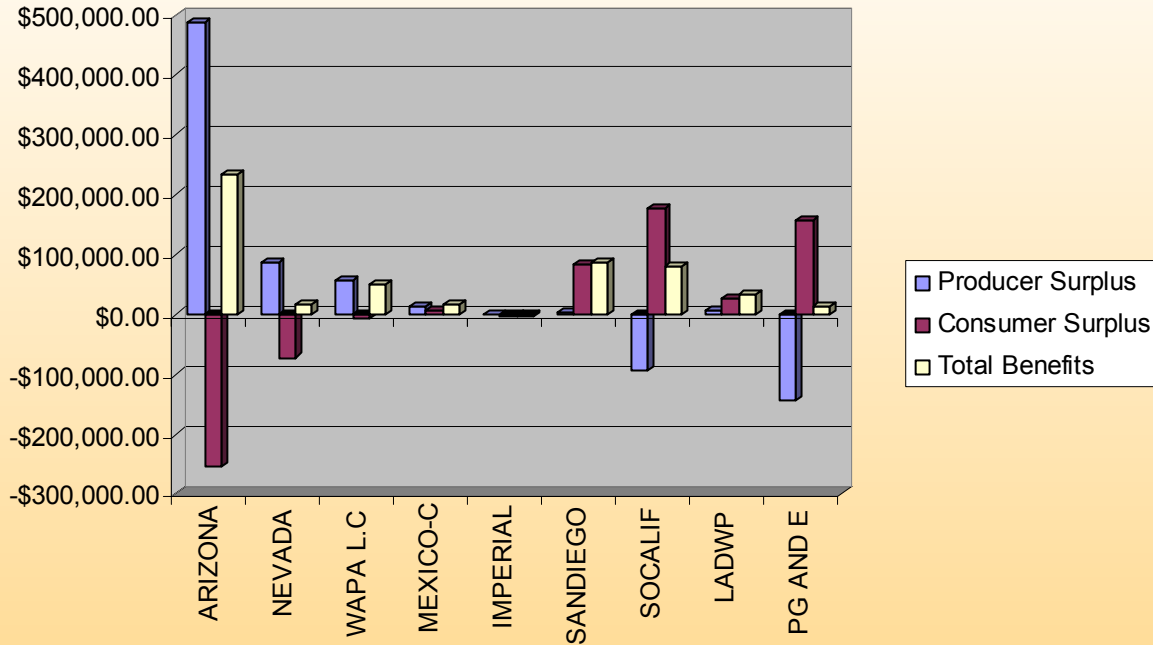
	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$248,940.78	-\$19,006.01	\$4,685.81	\$7,762.79	-\$58.80	\$4,141.69	-\$20,526.00	-\$1,653.30	-\$55,946.91	\$134,211.98	-\$72,331.21
CS	-\$101,285.00	\$14,610.00	-\$3,125.00	-\$7,799.00	-\$735.00	\$8,586.00	\$41,736.00	\$16,745.00	\$73,712.00	\$72,204.00	\$124,034.00
TB	\$147,655.78	-\$4,396.01	\$1,560.81	-\$36.21	-\$793.80	\$12,727.69	\$21,210.00	\$15,091.70	\$17,765.09	\$206,415.98	\$51,702.79



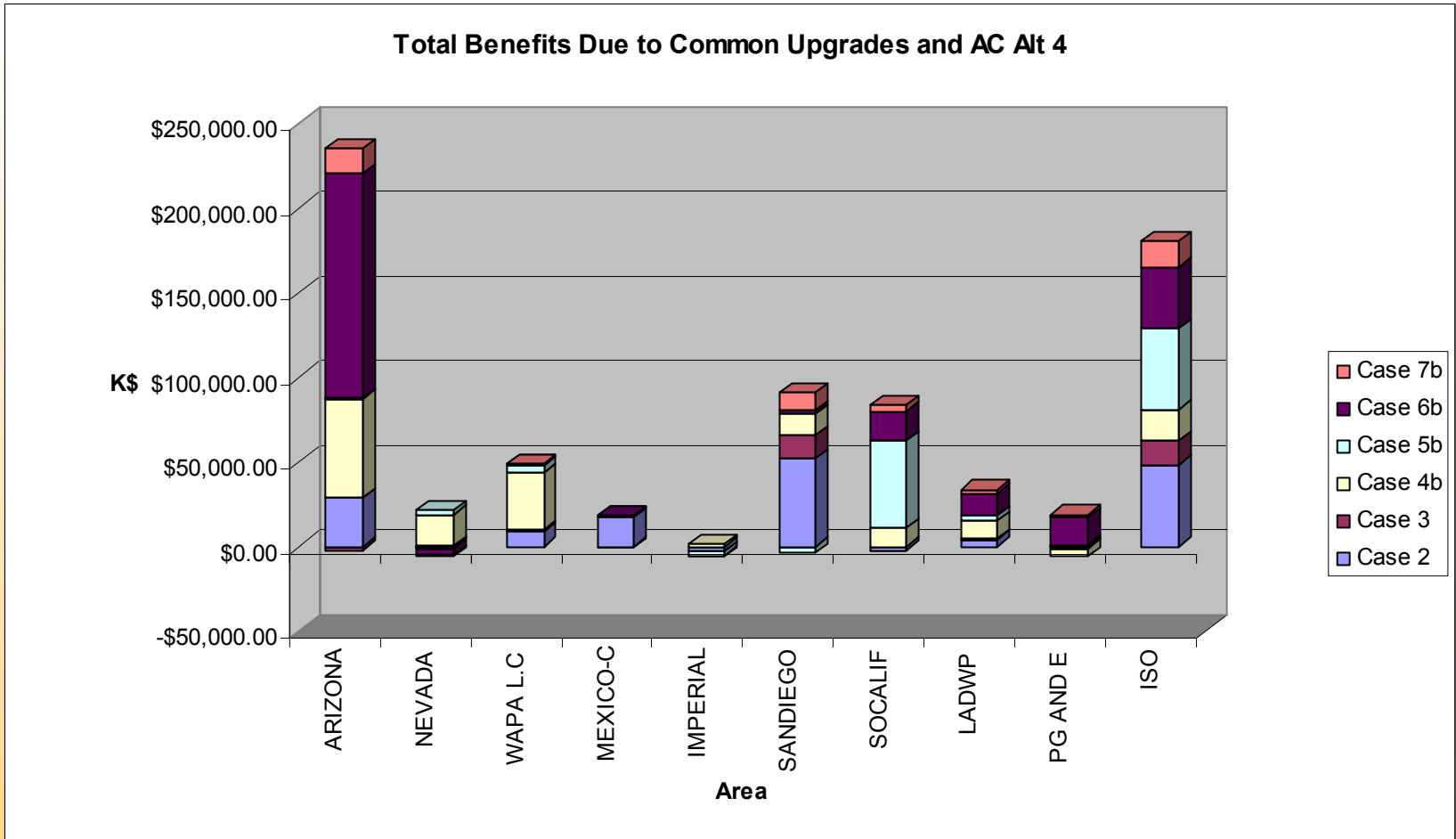
# CALIFORNIA ISO

California Independent System Operator

## Total Accumulative Benefits Due Common Upgrades and AC Alt 4



	ARIZONA	NEVADA	WAPA L.C	MEXICO-C	IMPERIAL	SANDIEGO	SOCALIF	LADWP	PG AND E	Total WECC	ISO
PS	\$487,333.53	\$87,964.51	\$55,741.31	\$11,863.91	\$121.90	\$4,621.90	-\$94,447.81	\$6,122.40	-\$142,844.89	\$364,470.93	-\$232,670.81
CS	-\$254,304.00	-\$71,998.00	-\$6,662.00	\$6,068.00	-\$4,521.00	\$82,118.00	\$175,407.00	\$27,642.00	\$156,011.00	\$152,797.00	\$413,536.00
TB	\$233,029.53	\$15,966.51	\$49,079.31	\$17,931.91	-\$4,399.10	\$86,739.90	\$80,959.19	\$33,764.40	\$13,166.11	\$517,267.93	\$180,865.19



**Case 6b: Common upgrades and two phase shifters on CA/NV tie lines**  
**Case 7b: Case 6b with IV - Ramona**



# CALIFORNIA ISO

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