

Western Wind & Solar Integration Study

Operational Impacts

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Stakeholder Meeting
August 14, 2008



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Scenarios

All cases run for 2017, hydro schedule and thermal unit commitment based on forecasted shapes.

- No wind or solar generation.
- Base wind generation installed by 12/31/08.
- In-Area site selection @10% , 20% and 30% energy penetration.
- In-Area site selection with perfect wind & solar forecasts for 10%, 20% and 30% scenarios.

2017 Baseline:	Preselected Wind, Embedded Solar
30% In-Area:	30% Wind, 5% Solar In Footprint 20% Wind, 3% Solar Out of Footprint
20% In-Area:	20% Wind, 3% Solar In Footprint 10% Wind, 1% Solar Out of Footprint
10% In-Area:	10% Wind, 1% Solar In Footprint 10% Wind, 1% Solar Out of Footprint
Solar Mix:	70% CSP with Storage, 30% PV

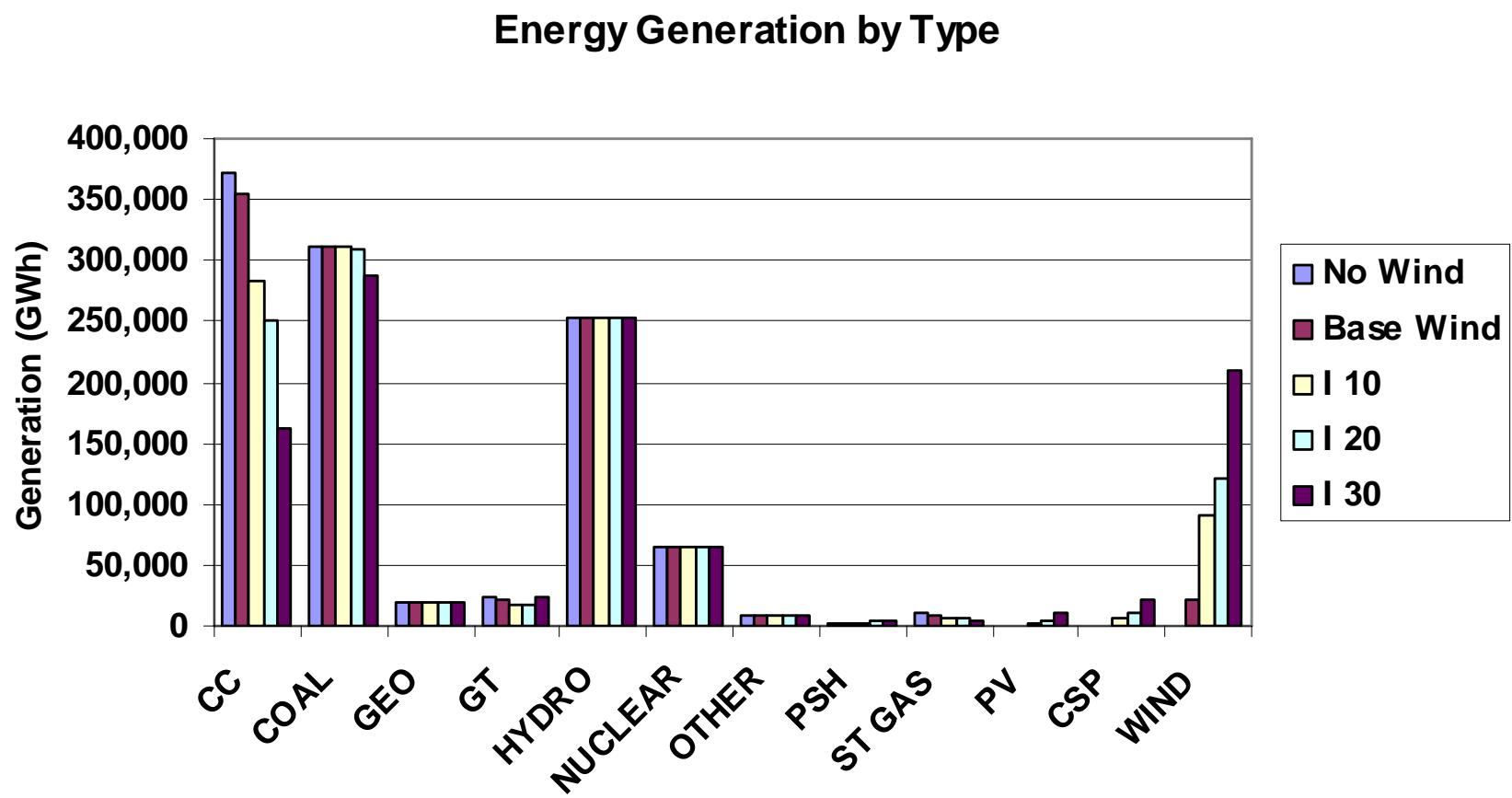


Data Assumptions

- Data based on Energy Velocity data for all of WECC
- Area load shapes inflated using NERC ES&D forecasts
- 2017 typical prices (regional and monthly variability applied)
 - Arizona Coal @ \$2.01/MBTu
 - Arizona Gas @ \$9.13/MBTu
 - Carbon tax @ \$5.10/ton

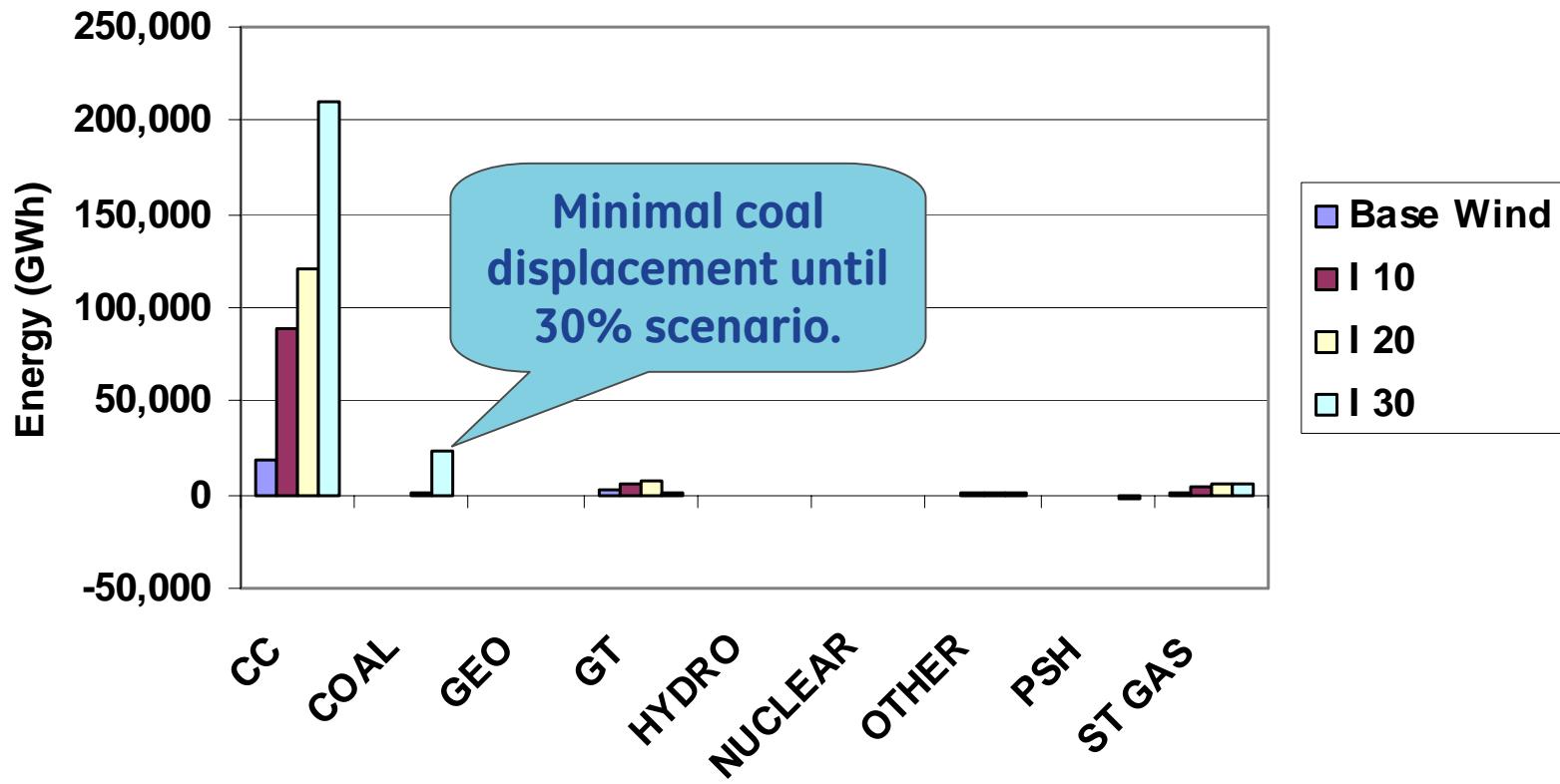


WECC Energy Generation by Type



WECC Energy Displacement (GWh)

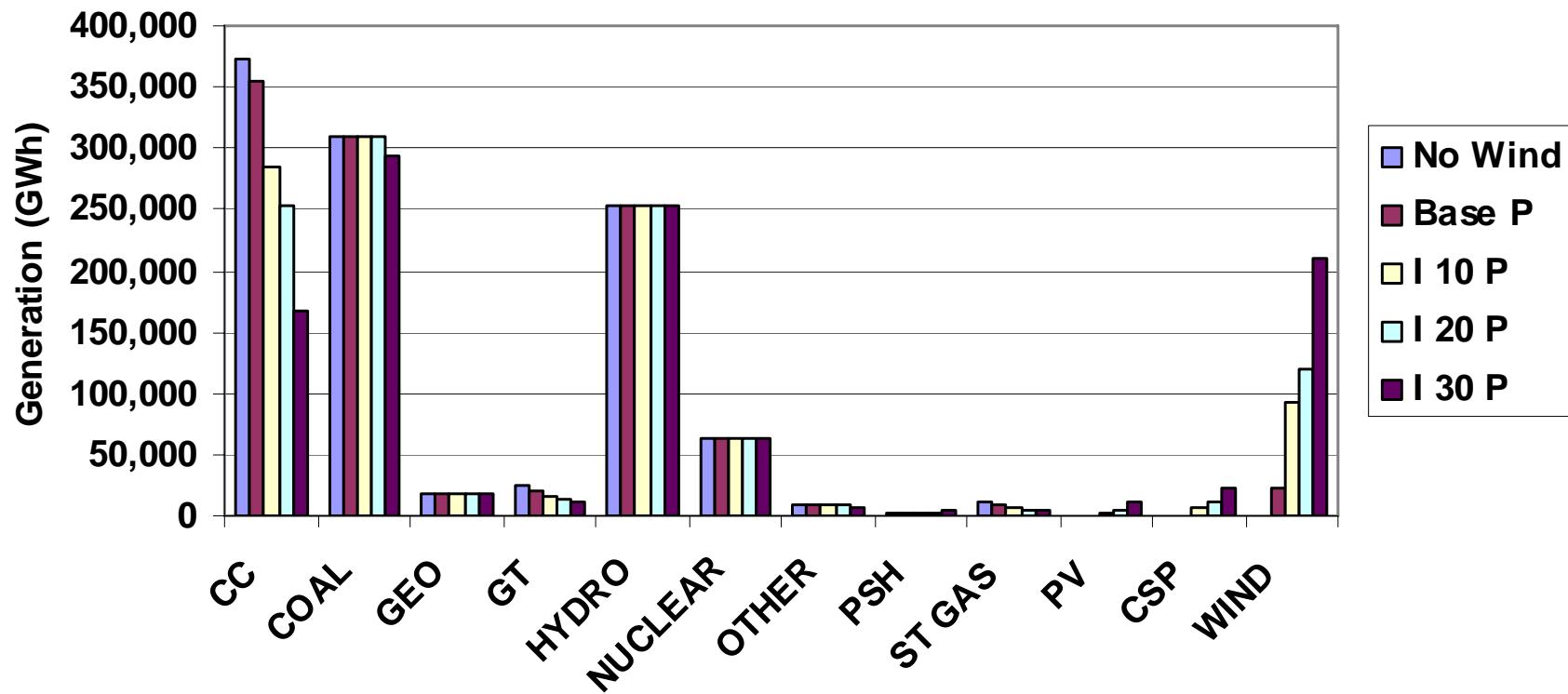
Energy Displacement (GWh)



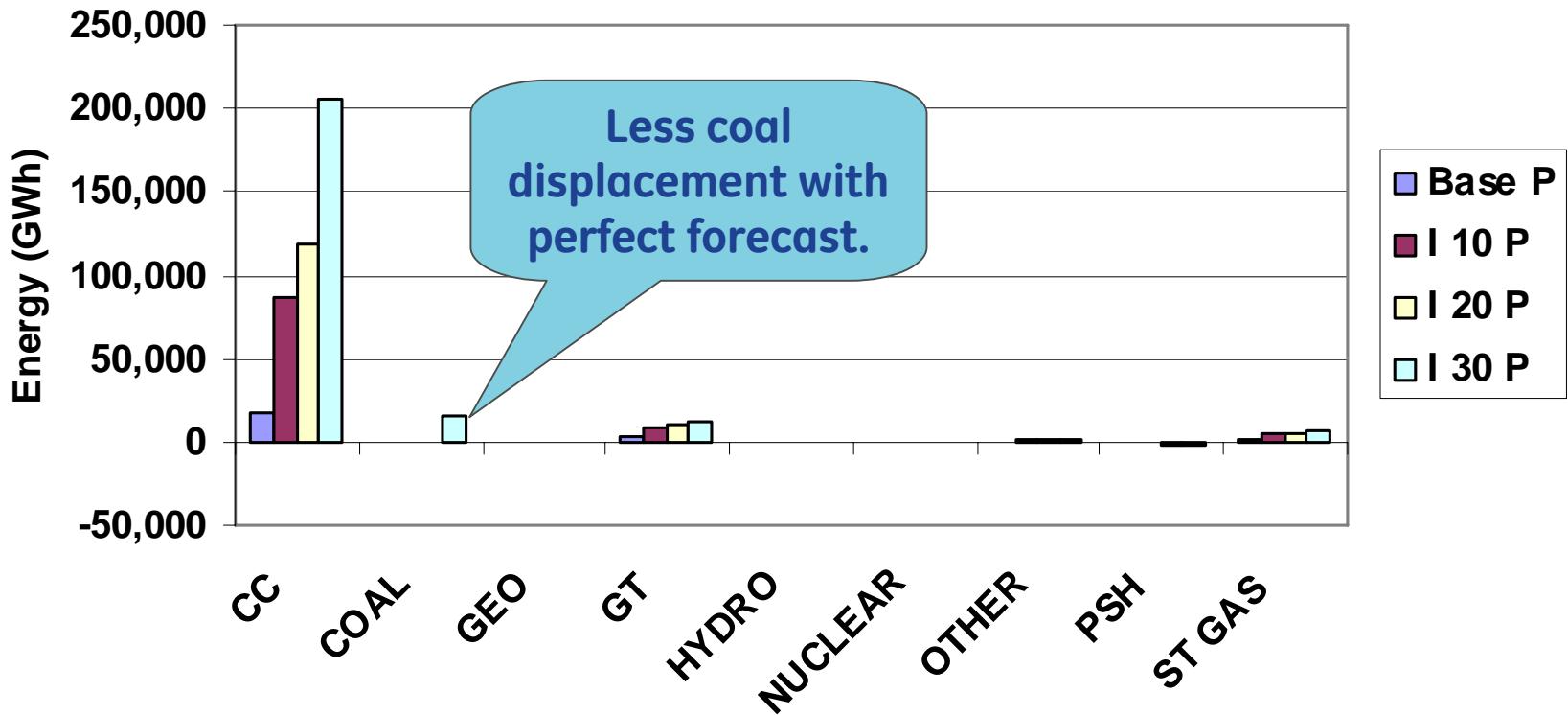
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WECC Energy Generation by Type

Perfect Wind & Solar Forecast

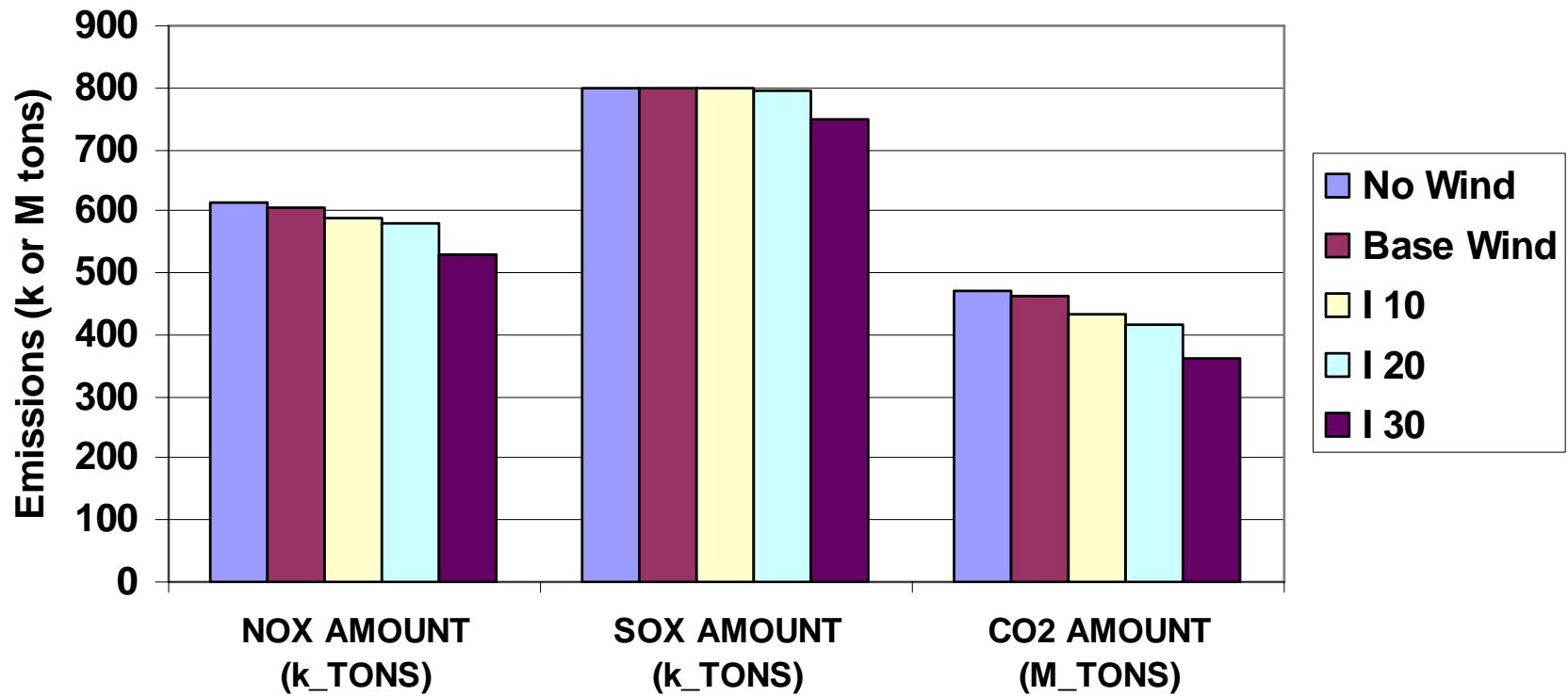


WECC Energy Displacement (GWh) Perfect Wind & Solar Forecast

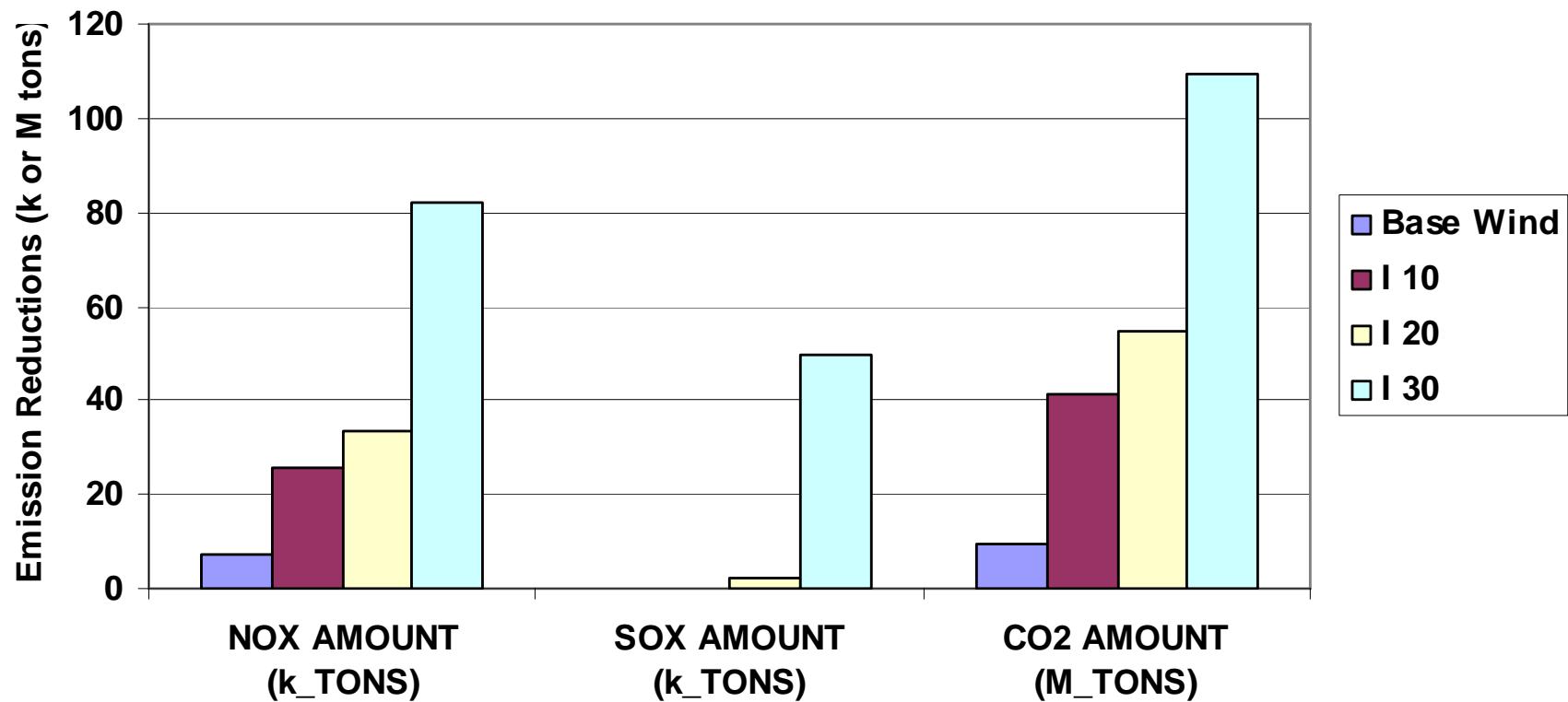


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WECC Total Emissions

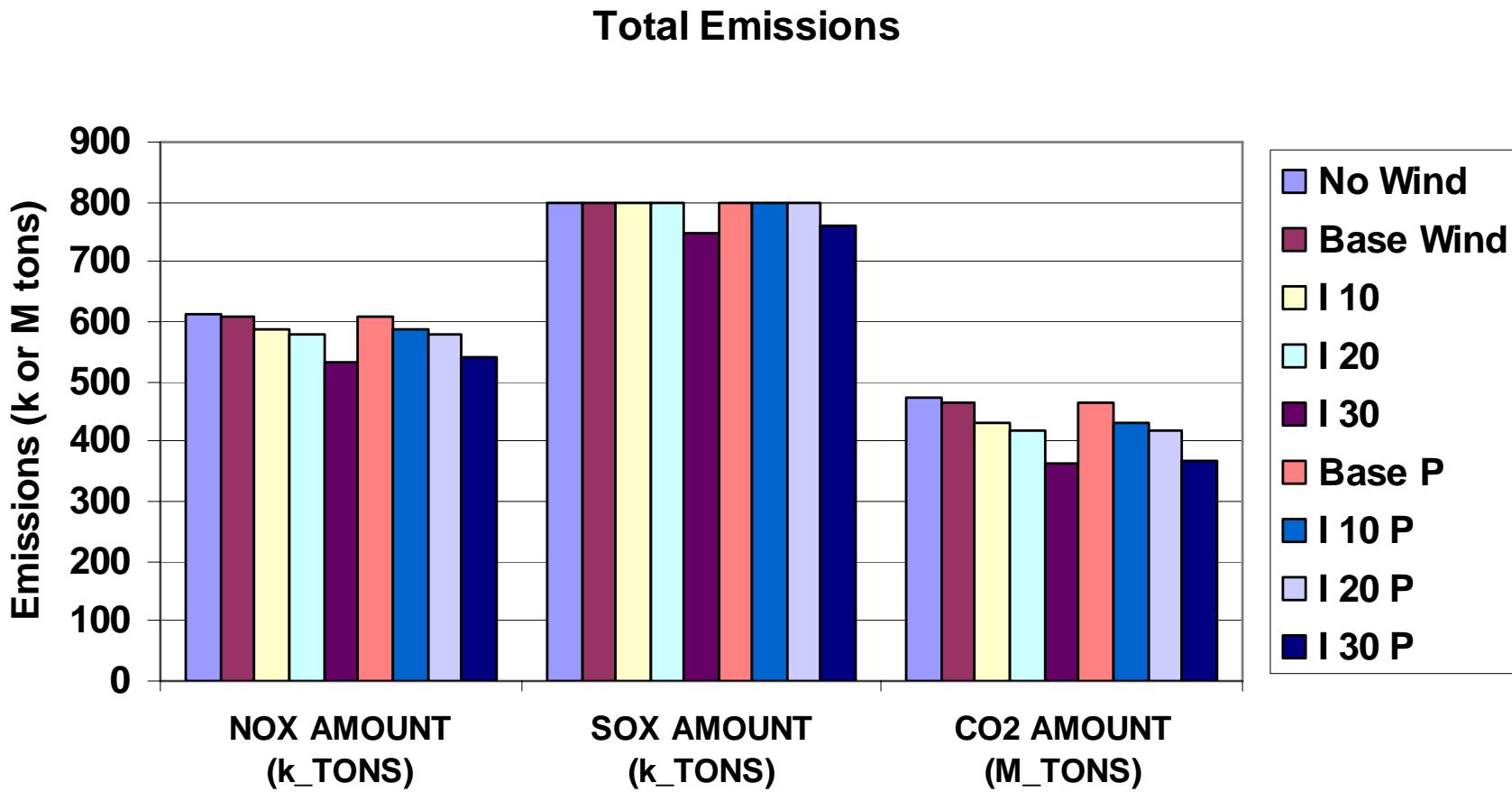


WECC Emission Reductions



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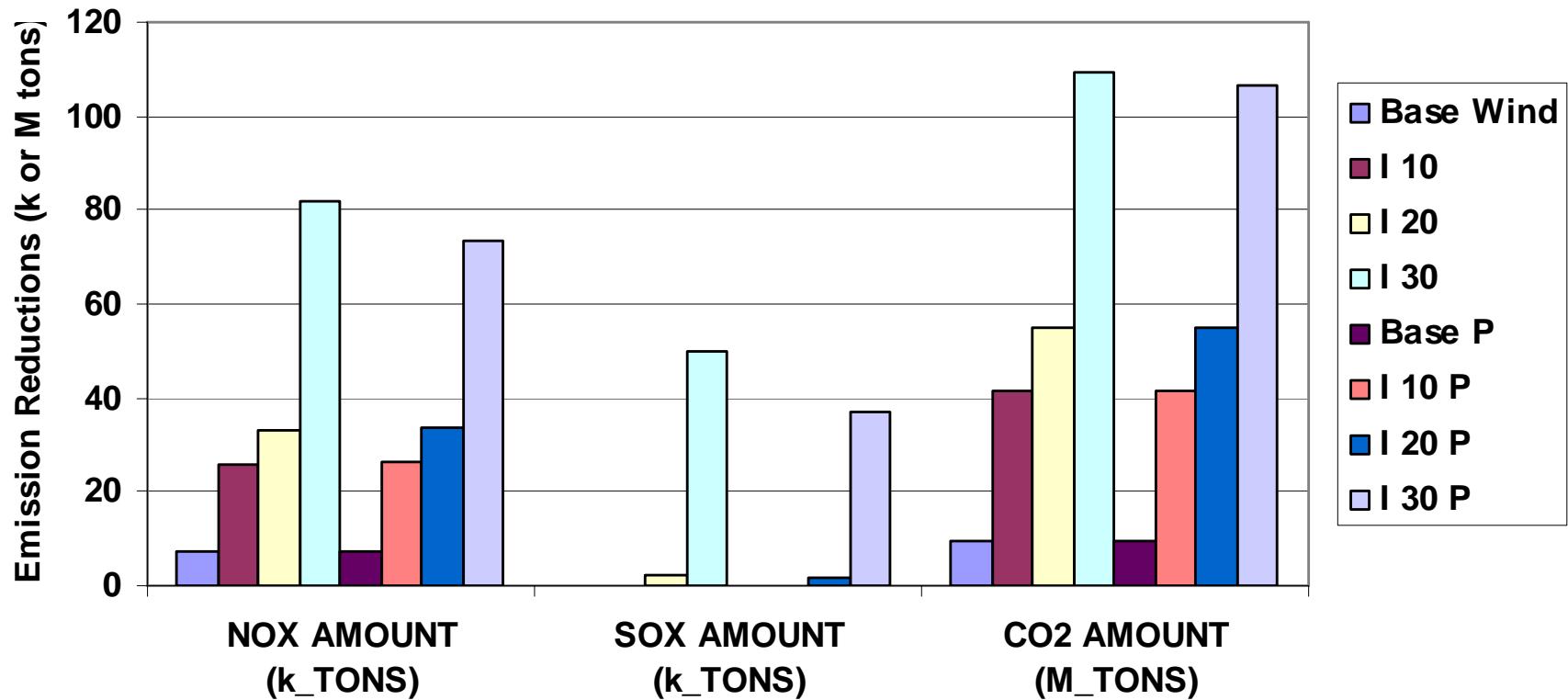
WECC Total Emissions (Perfect Forecasts)



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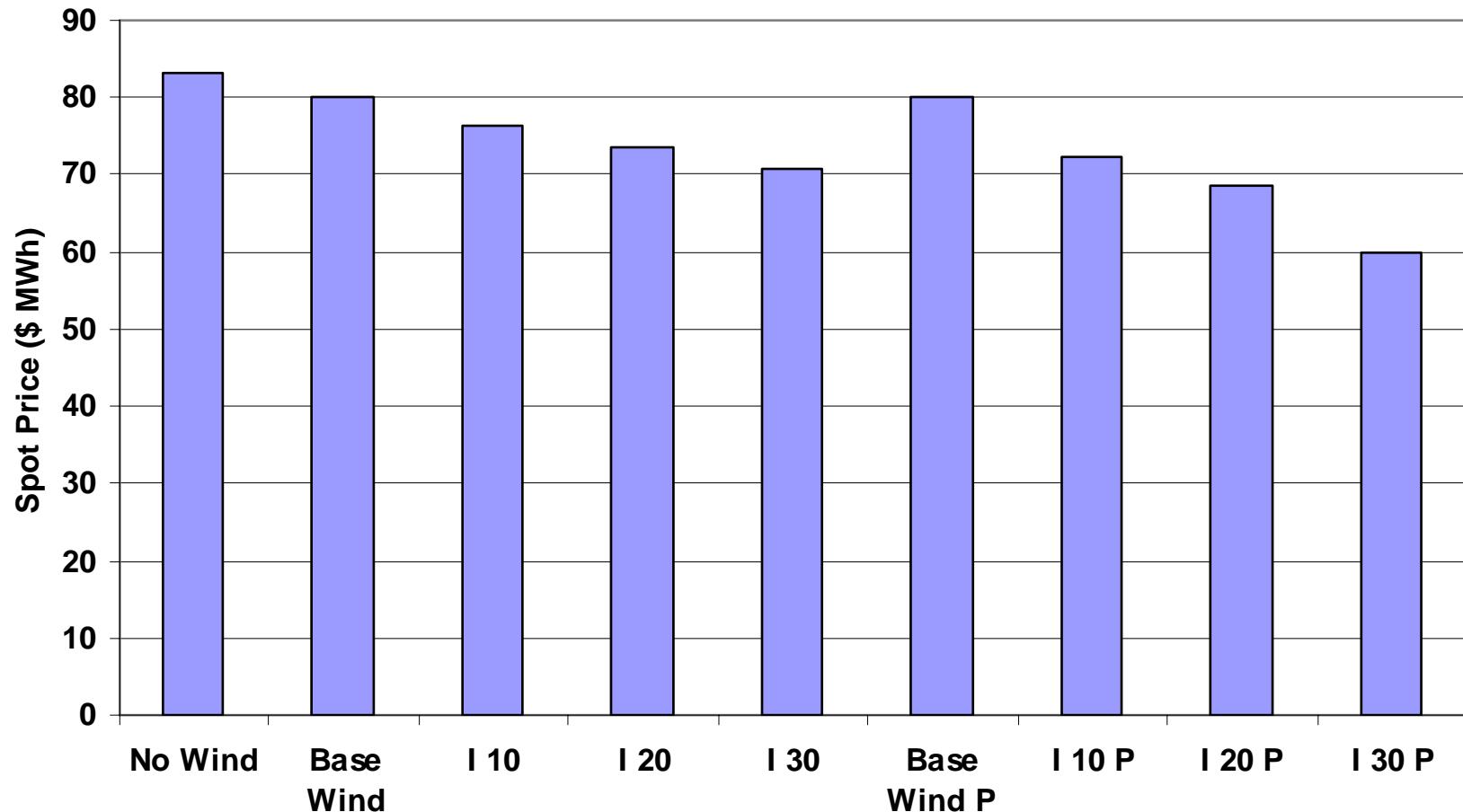
WECC Emission Reductions (Perfect Forecast)

Emission Reductions

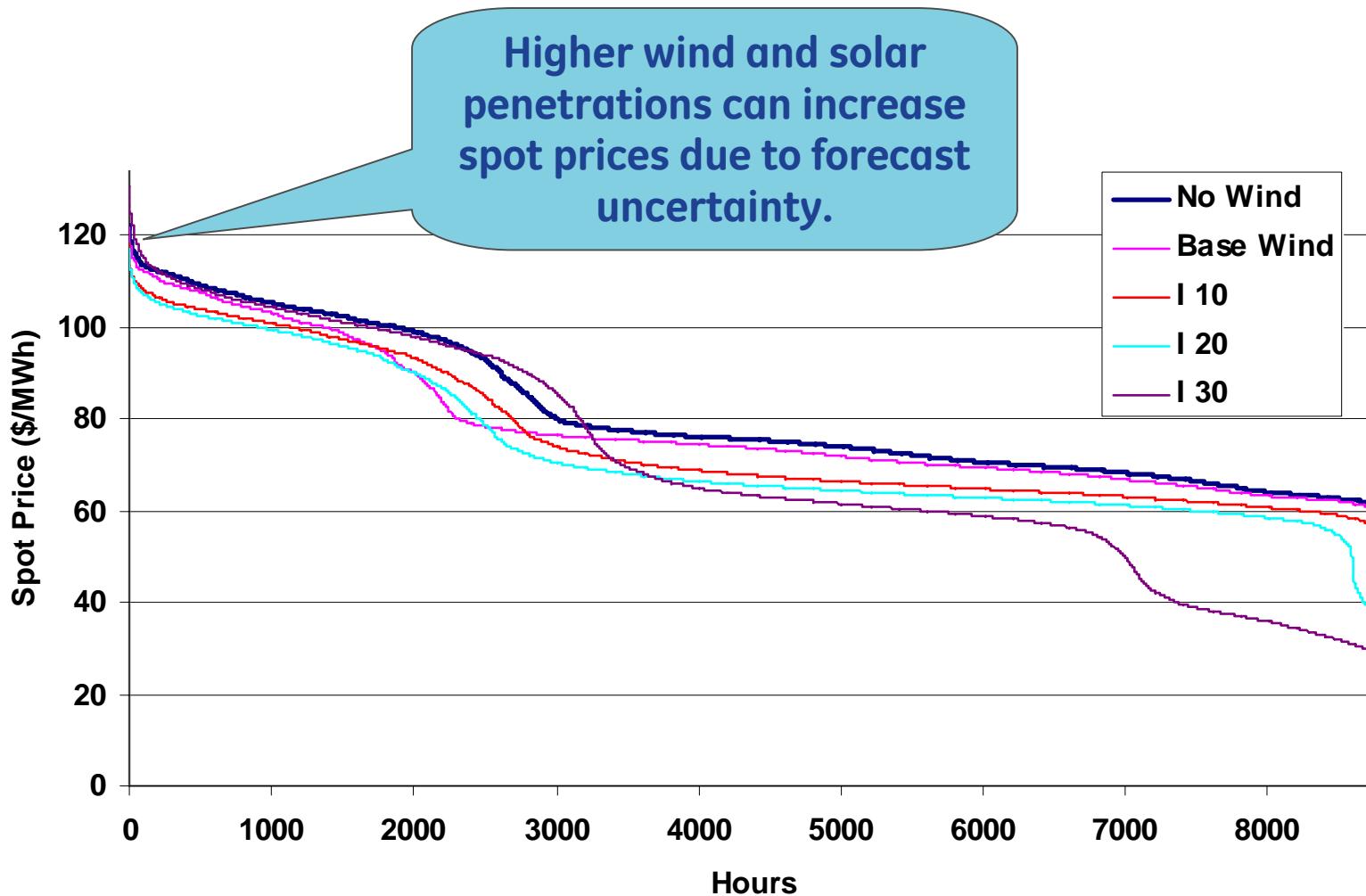


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WECC Average System Spot Price (\$/MWh)



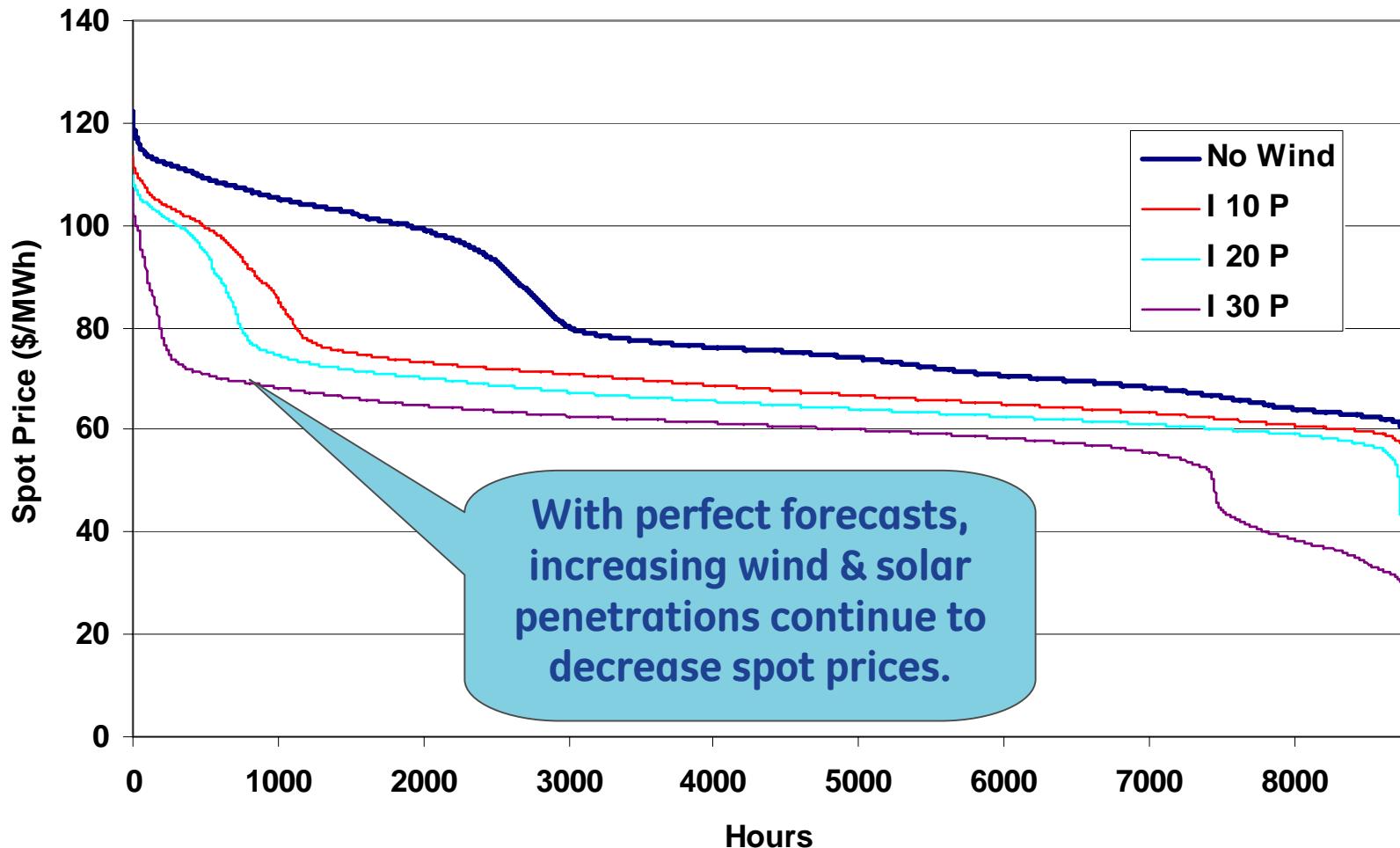
WECC System Spot Price Duration Curves (\$/MWh)



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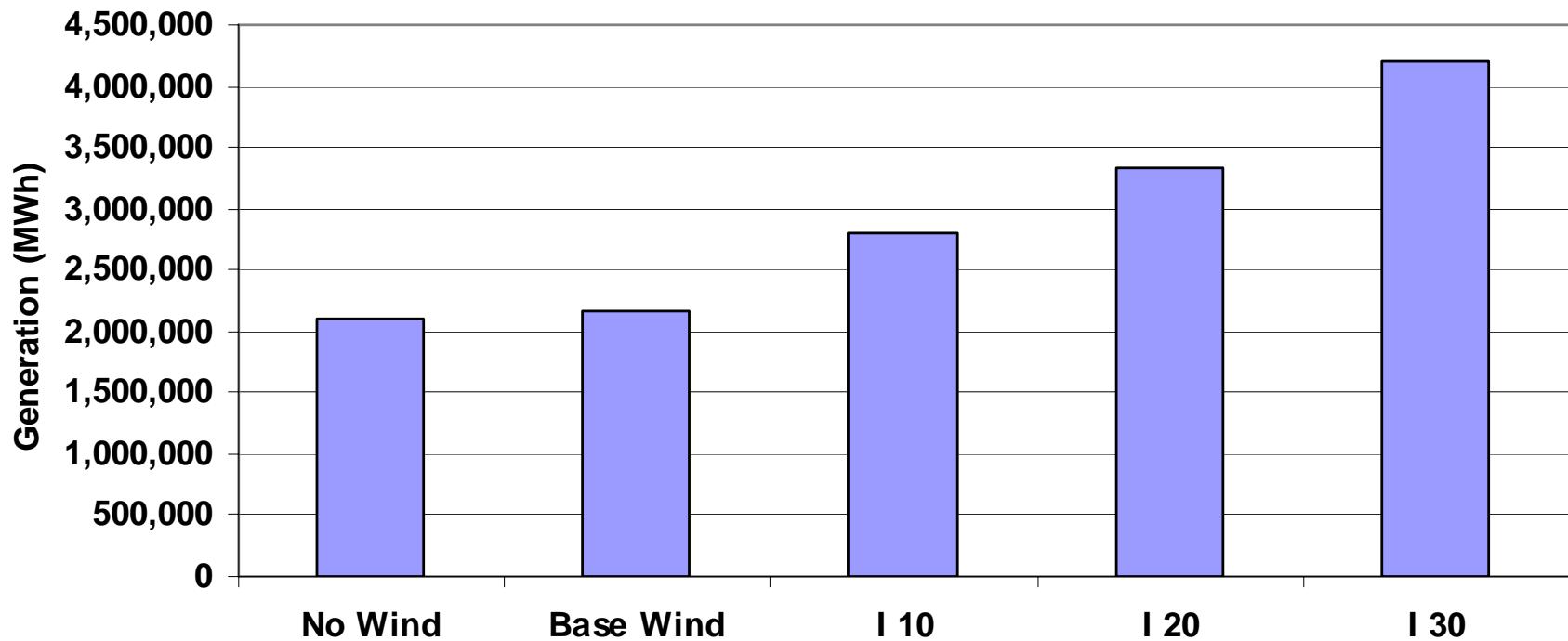
WECC System Spot Price Duration Curves (\$/MWh)

Perfect Wind & Solar Forecast

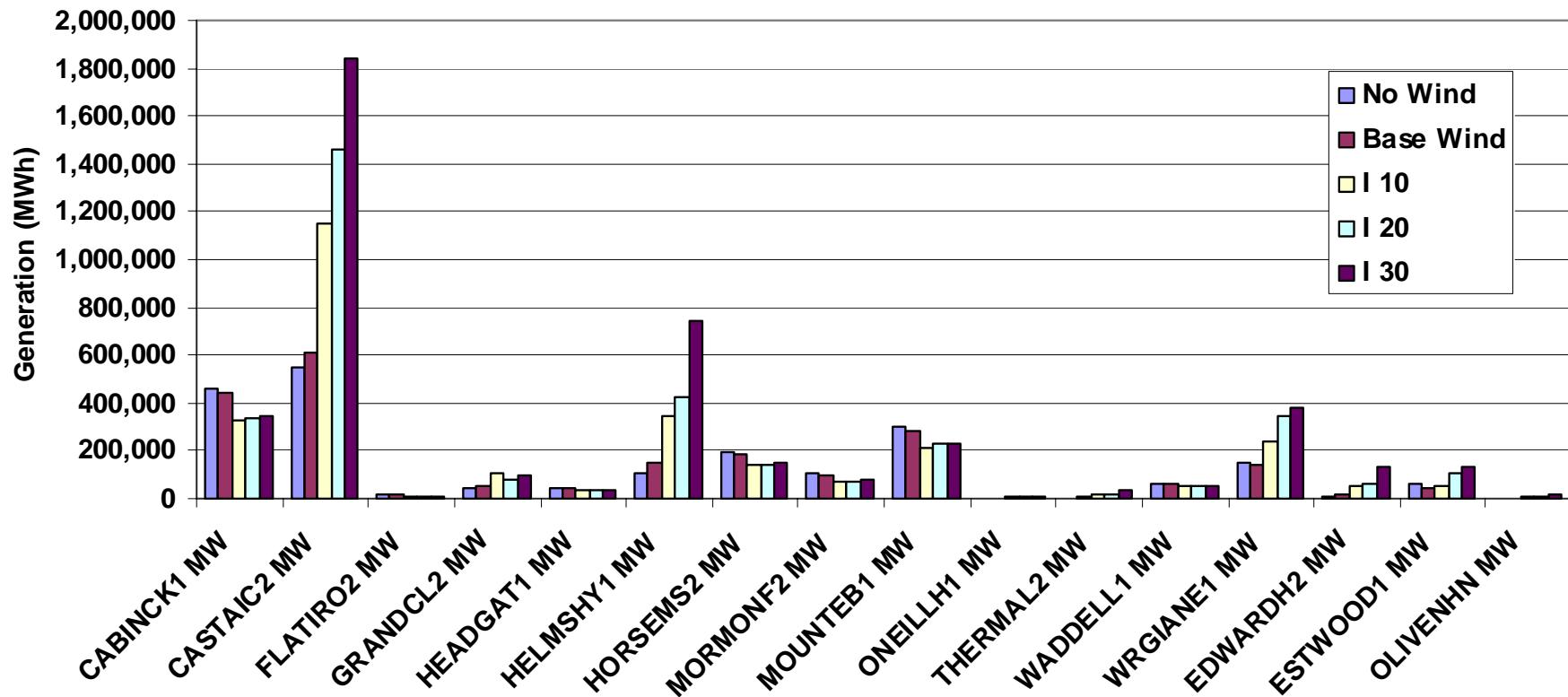


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WECC Total PSH Generation

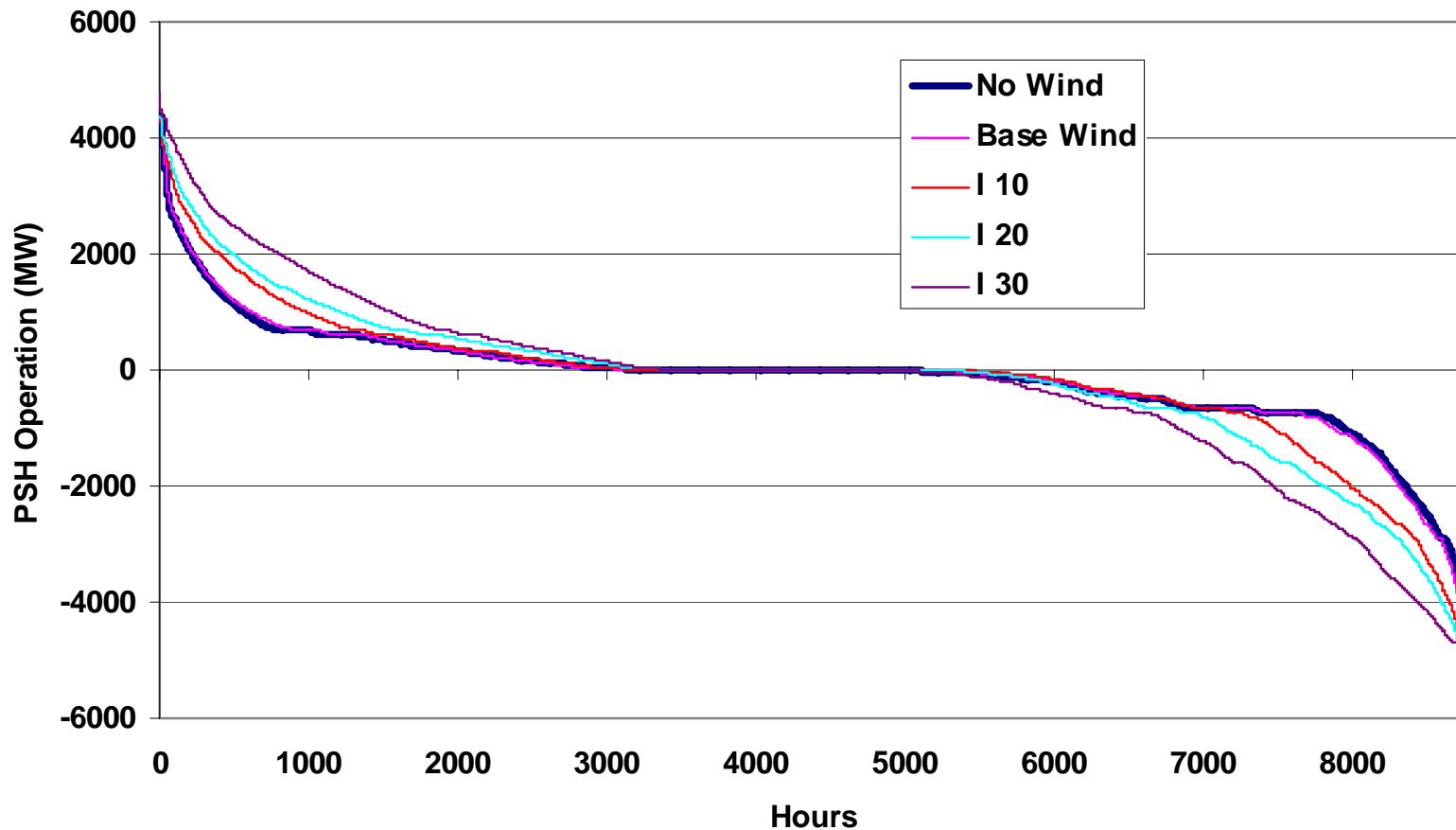


PSH Generation by Plant



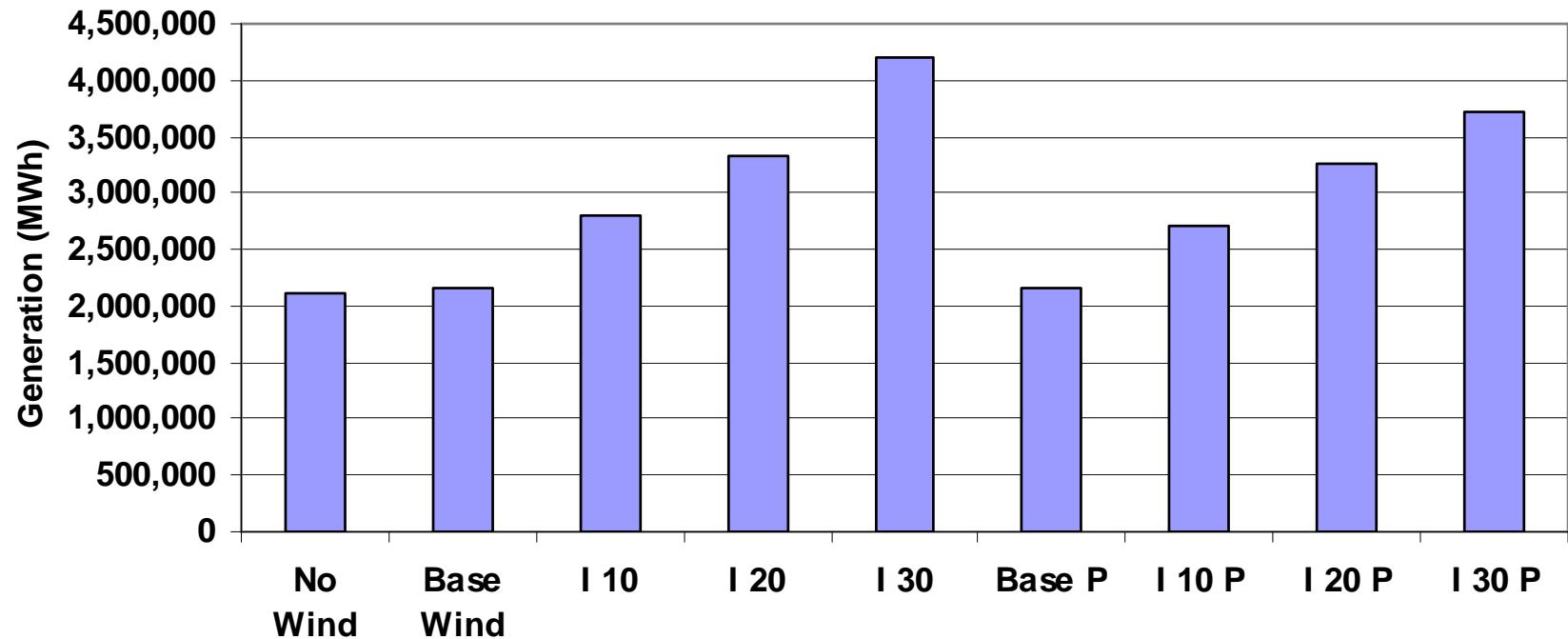
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WECC PSH Duration Curves



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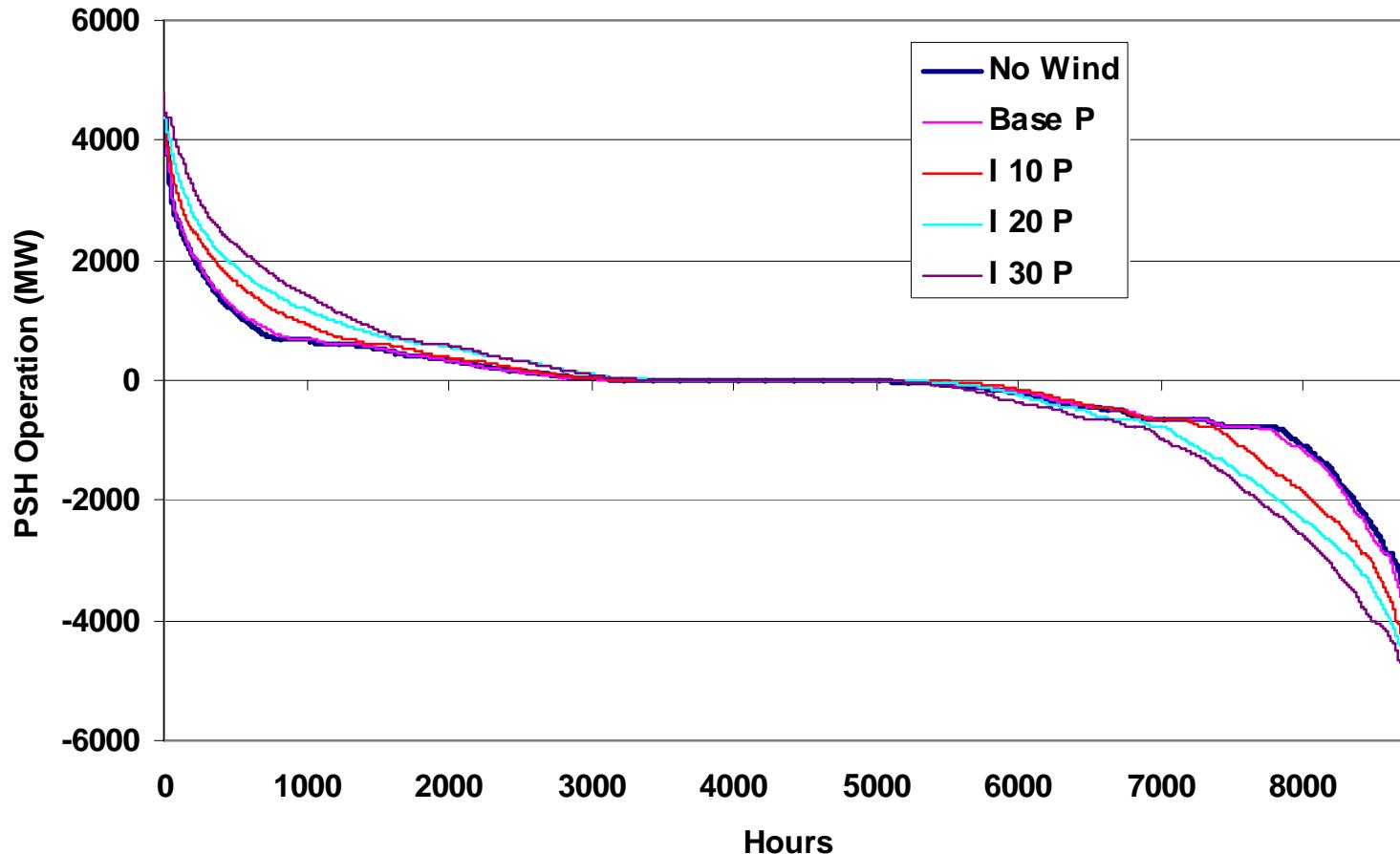
WECC Total PSH Generation (Perfect Forecast)



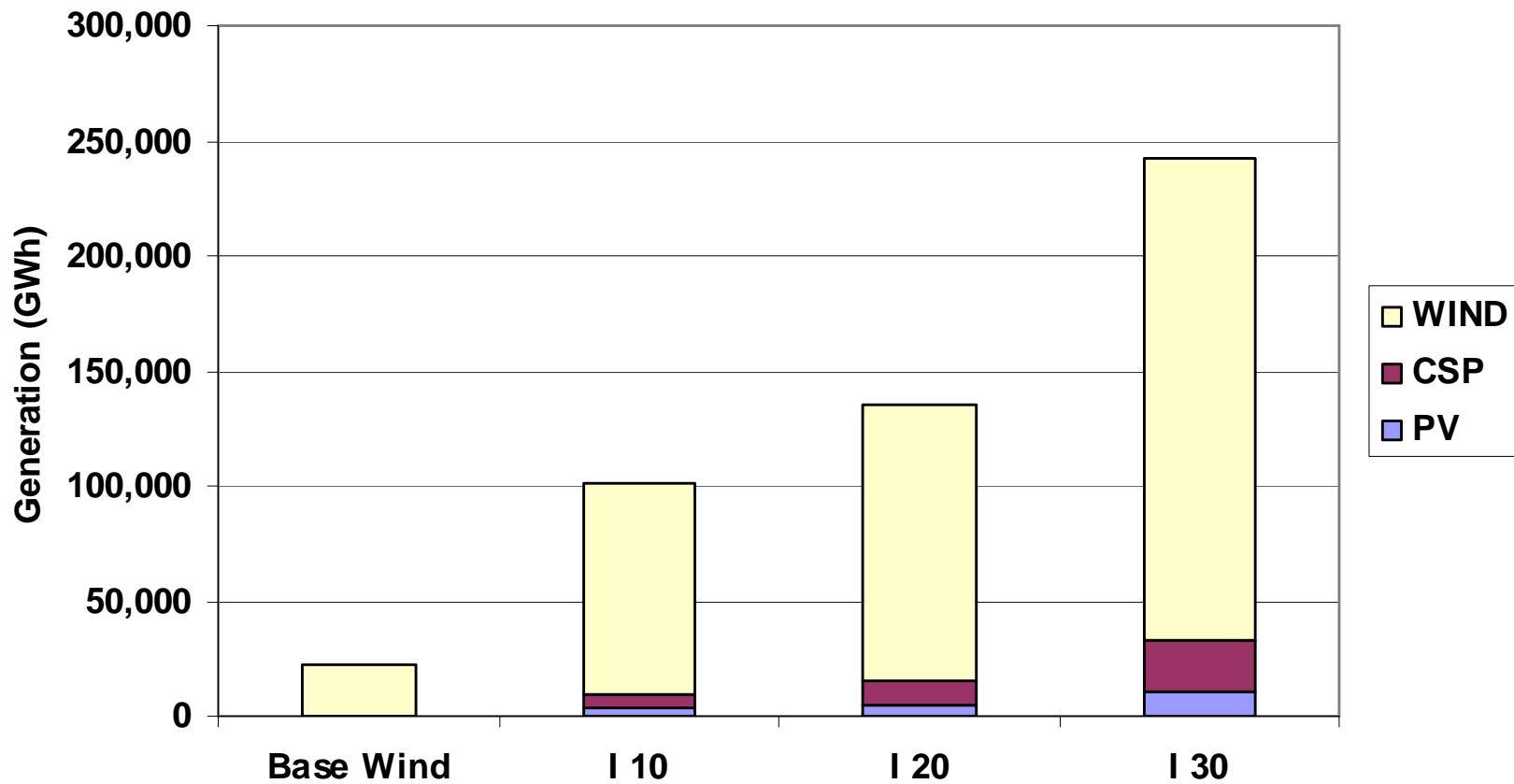
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WECC PSH Duration Curves

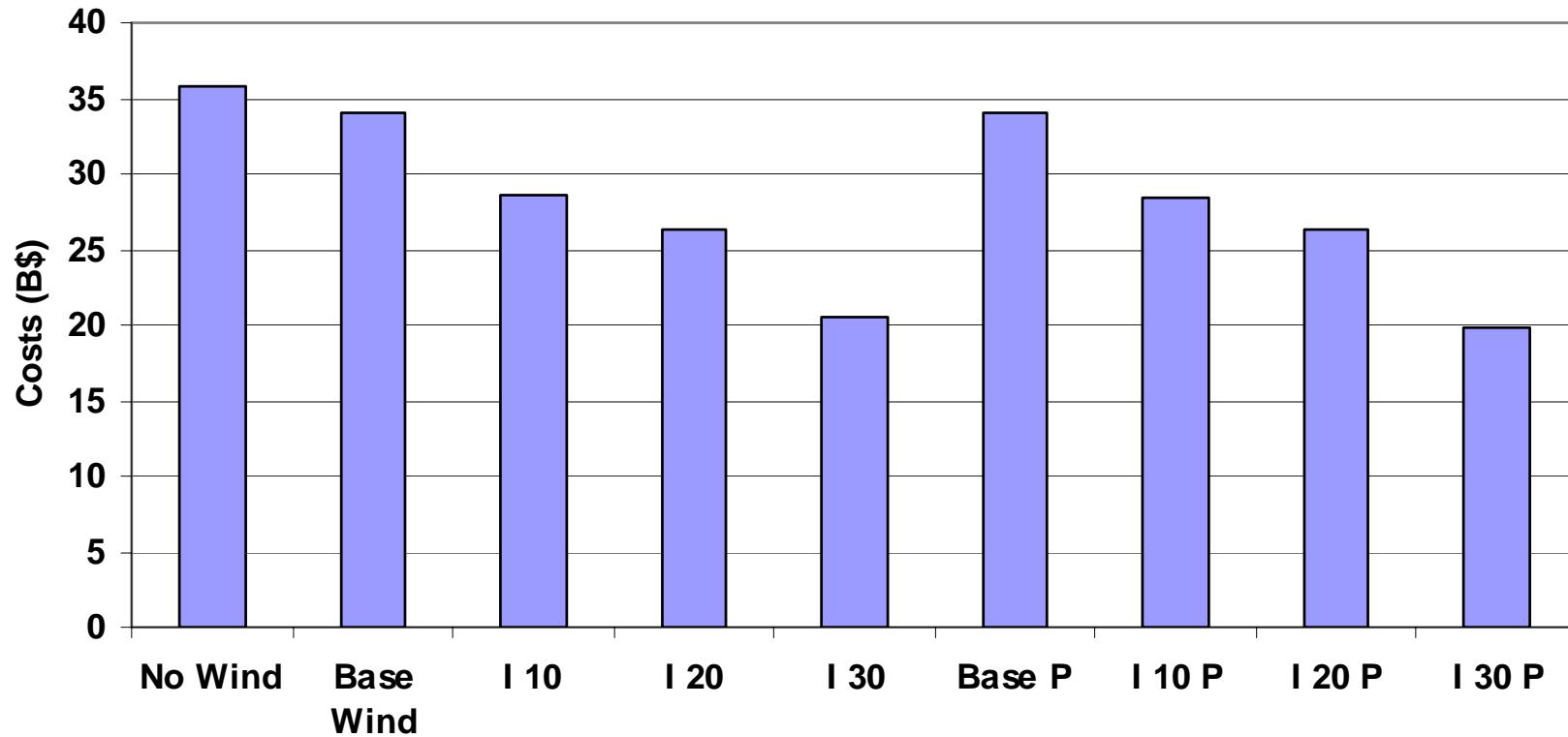
Perfect Wind & Solar Forecast



WECC Wind & Solar Generation (GWh)

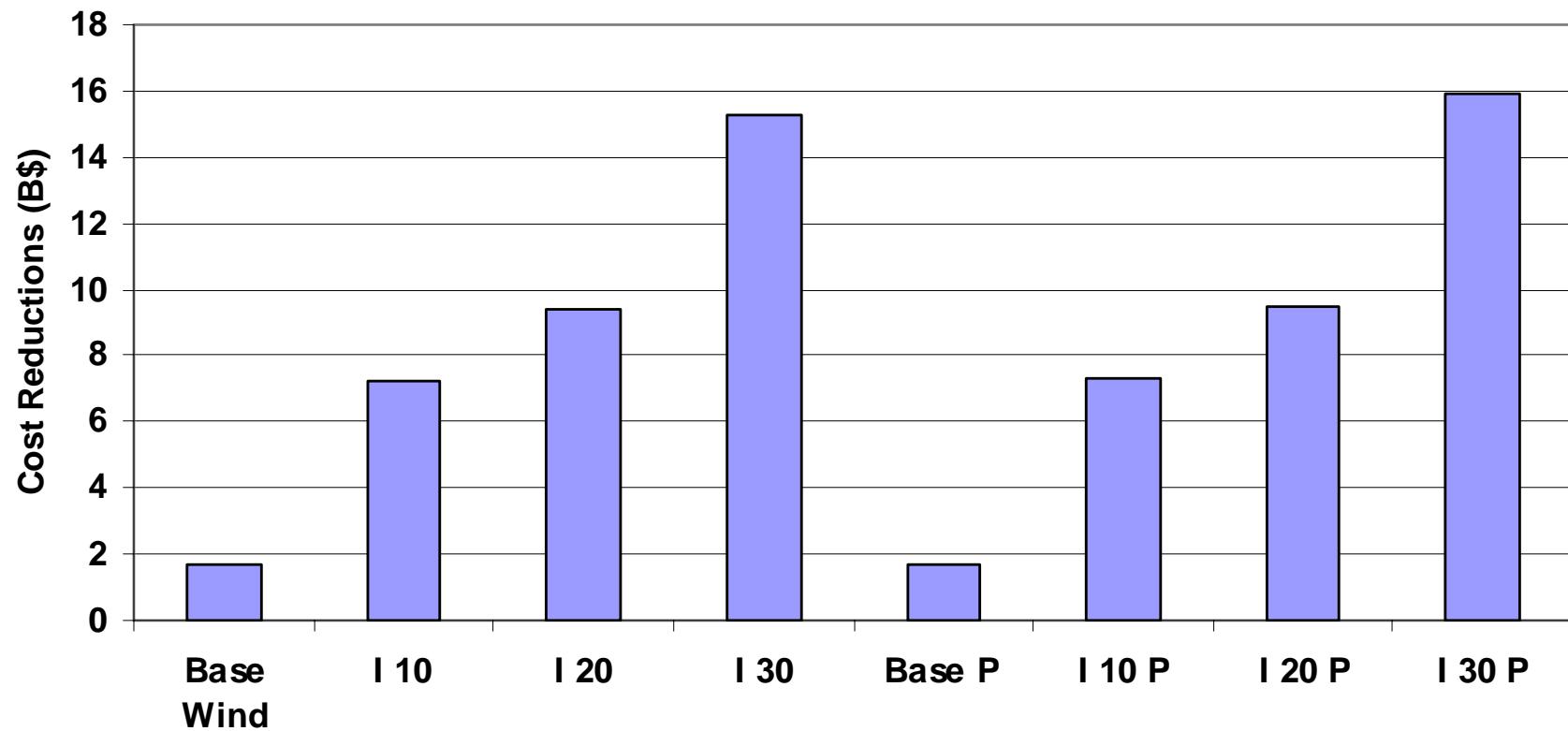


WECC Total Variable Operating Cost (B\$)

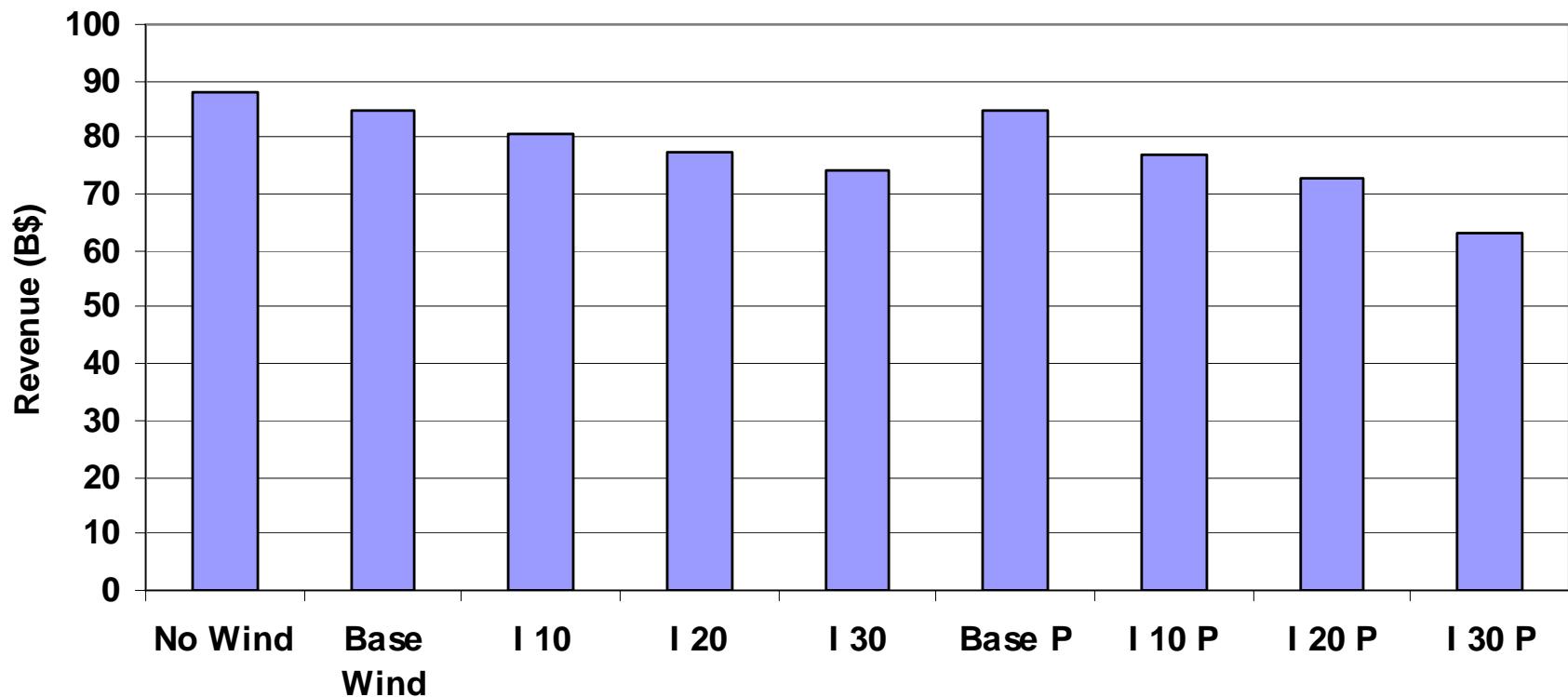


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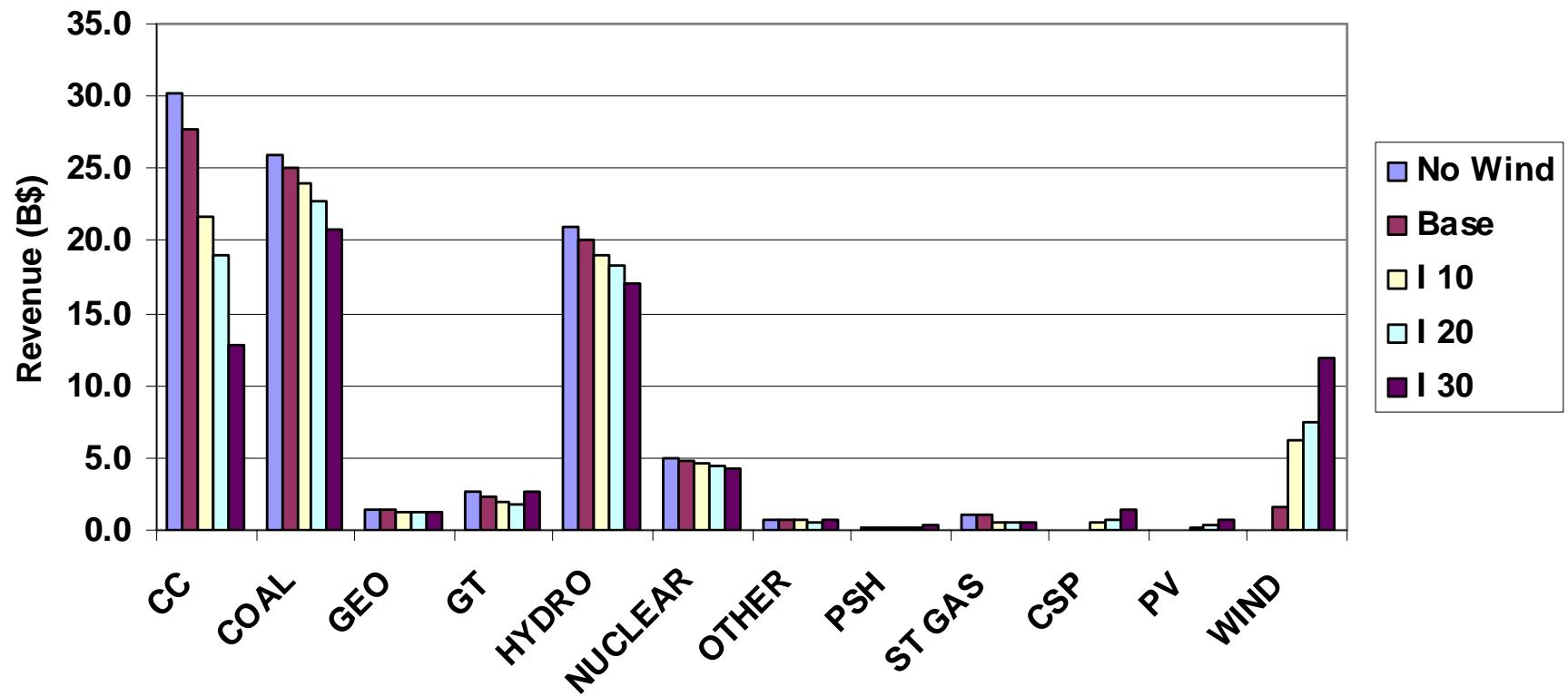
WECC Variable Cost Reductions (B\$)



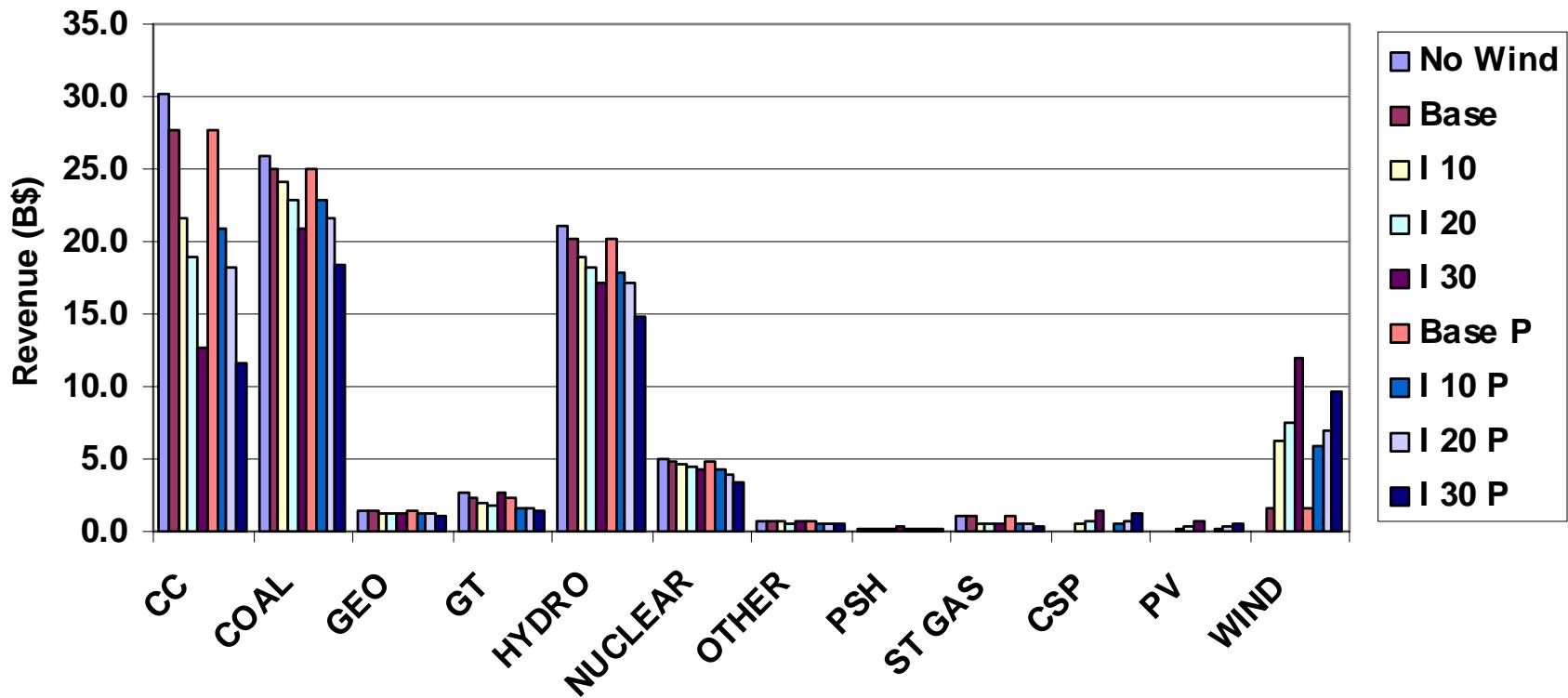
WECC Total Generator Revenue (B\$)



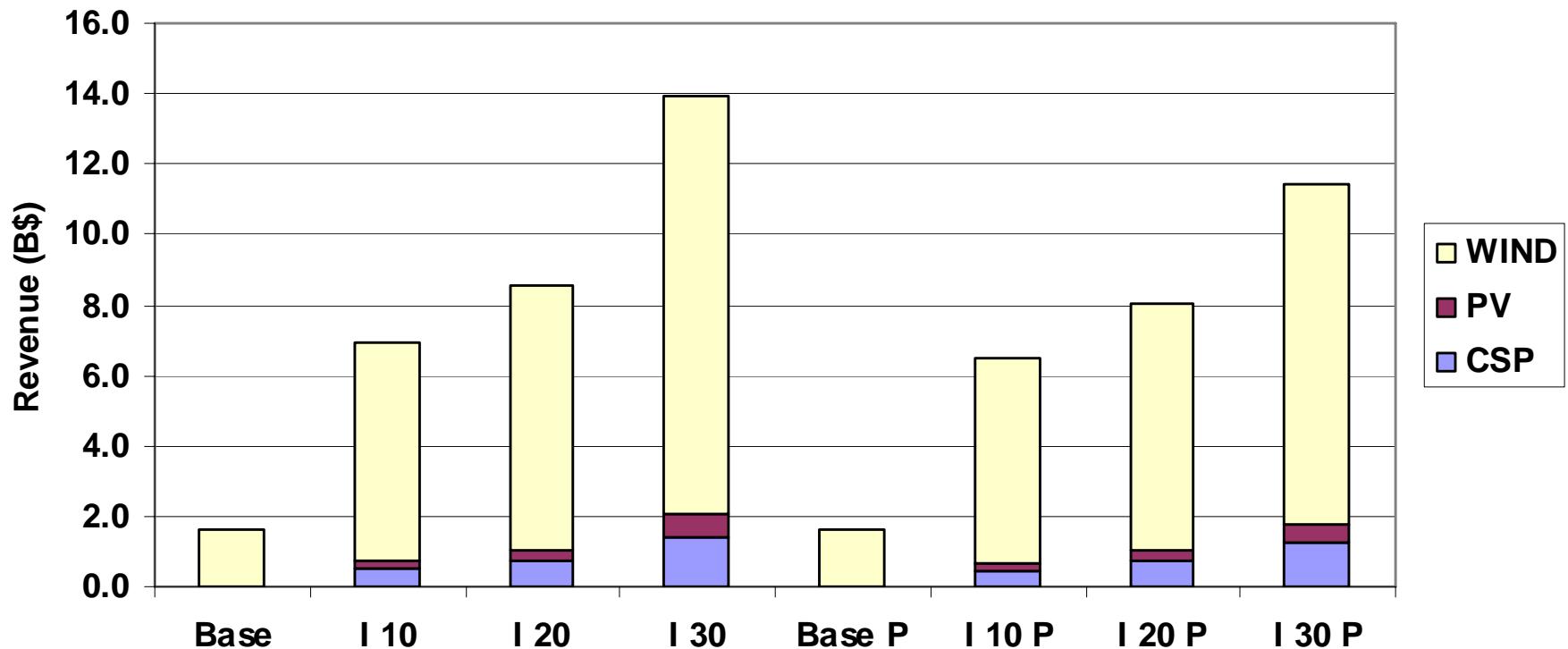
WECC Revenue by Generator Type (B\$)



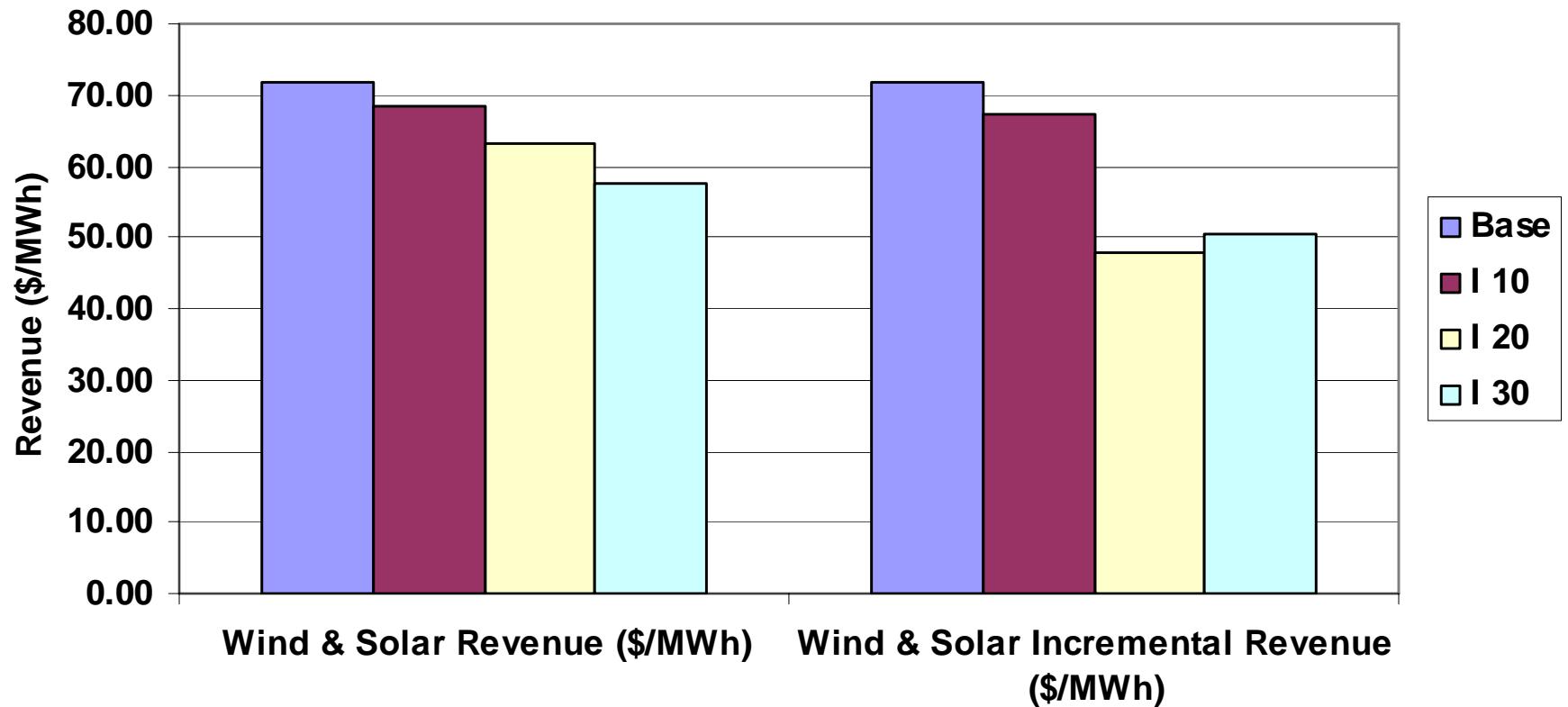
WECC Revenue by Generator Type (B\$) (Perfect Forecast)



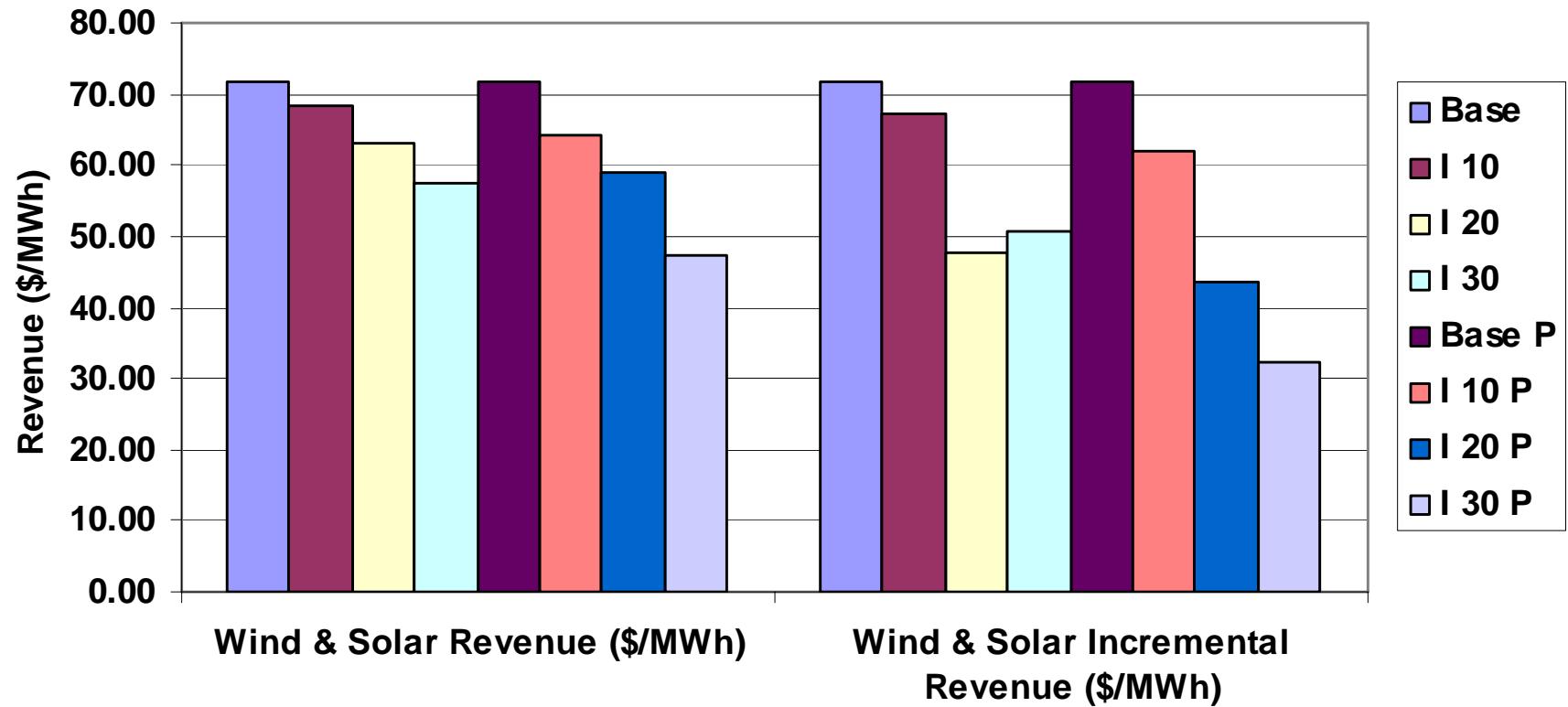
WECC Wind & Solar Revenue (B\$)



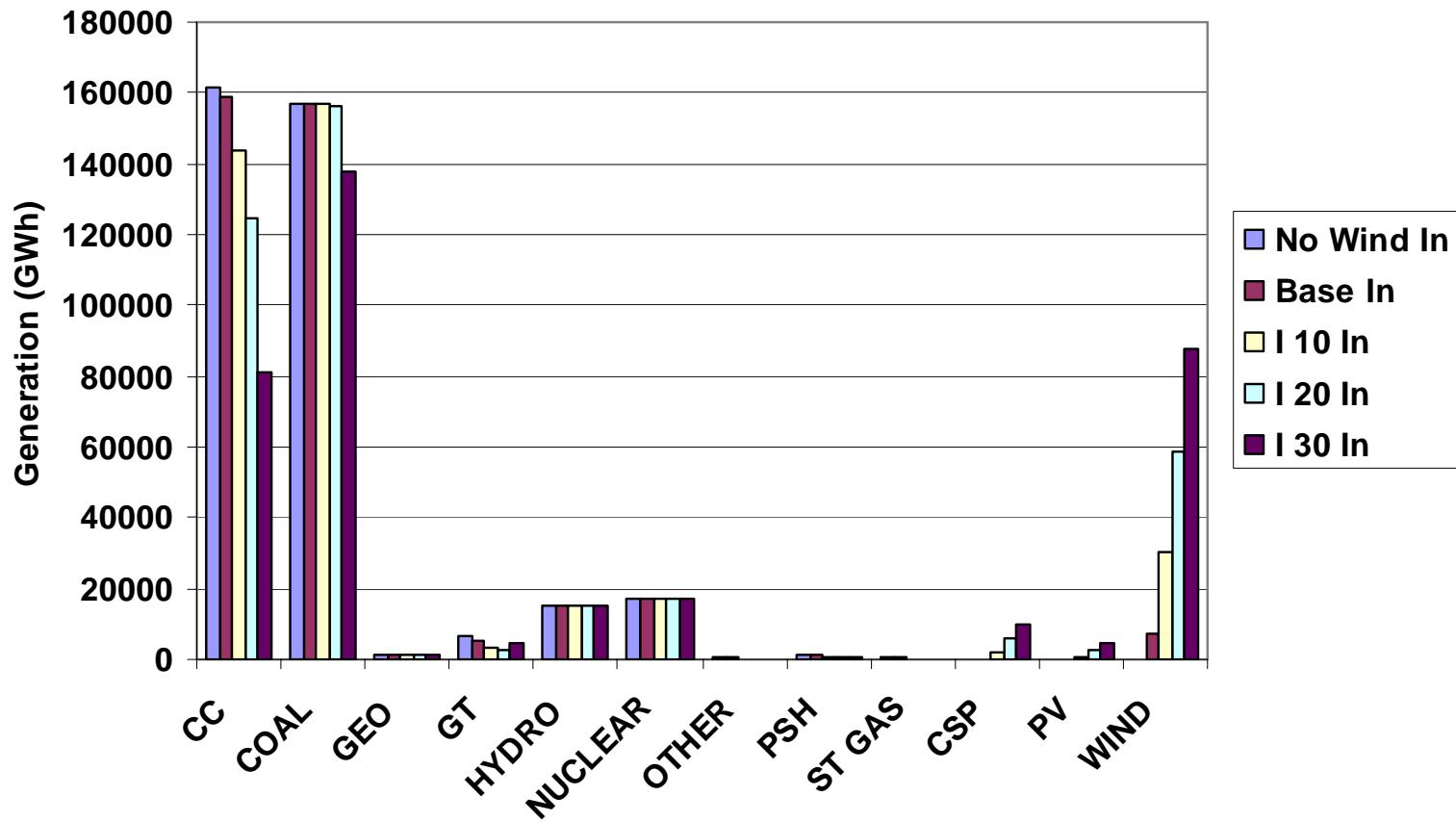
WECC Wind & Solar Revenue (\$/MWh)



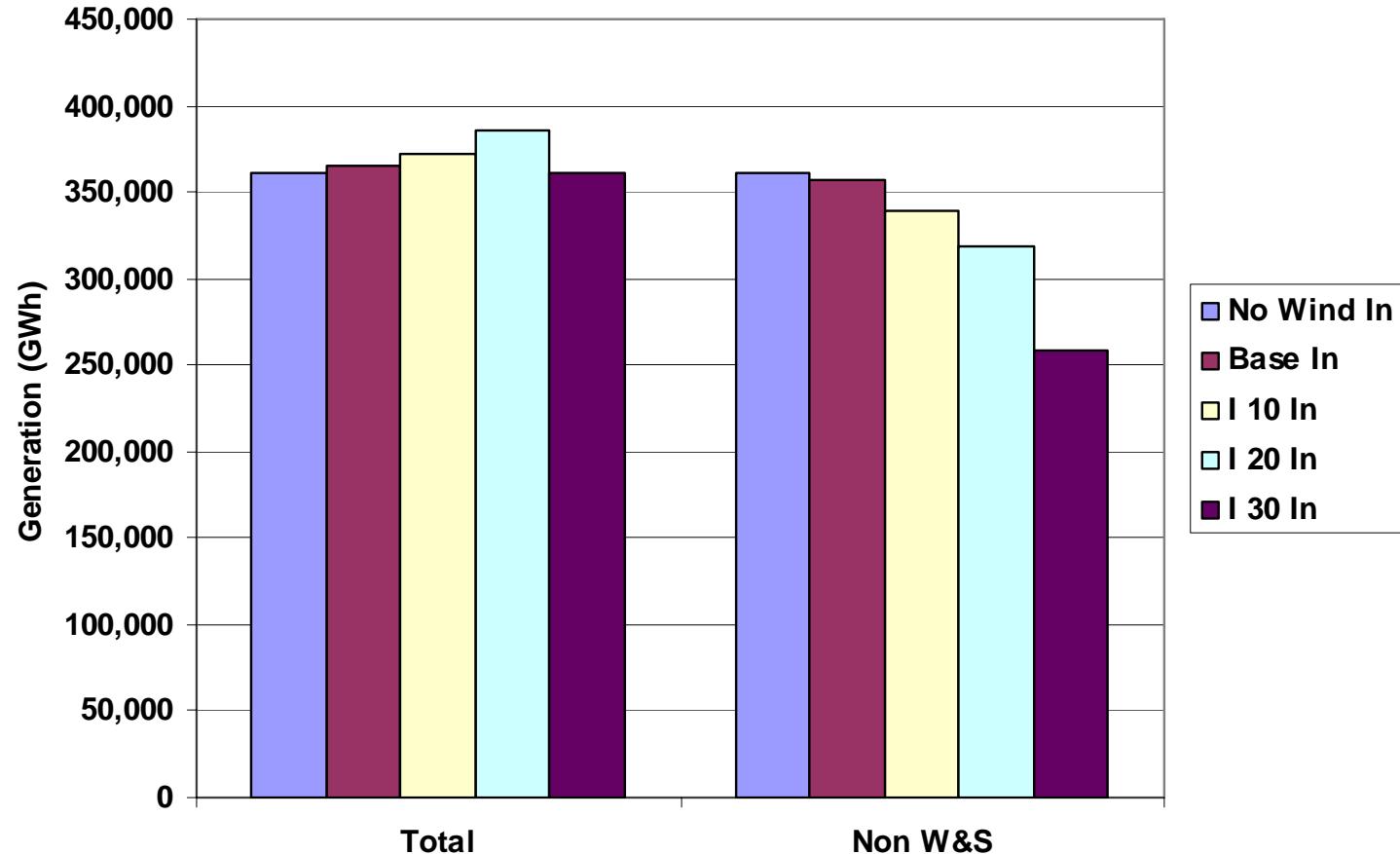
WECC Wind & Solar Revenue (\$/MWh) (Perfect Forecasts)



In Footprint Generation by Type (GWh)

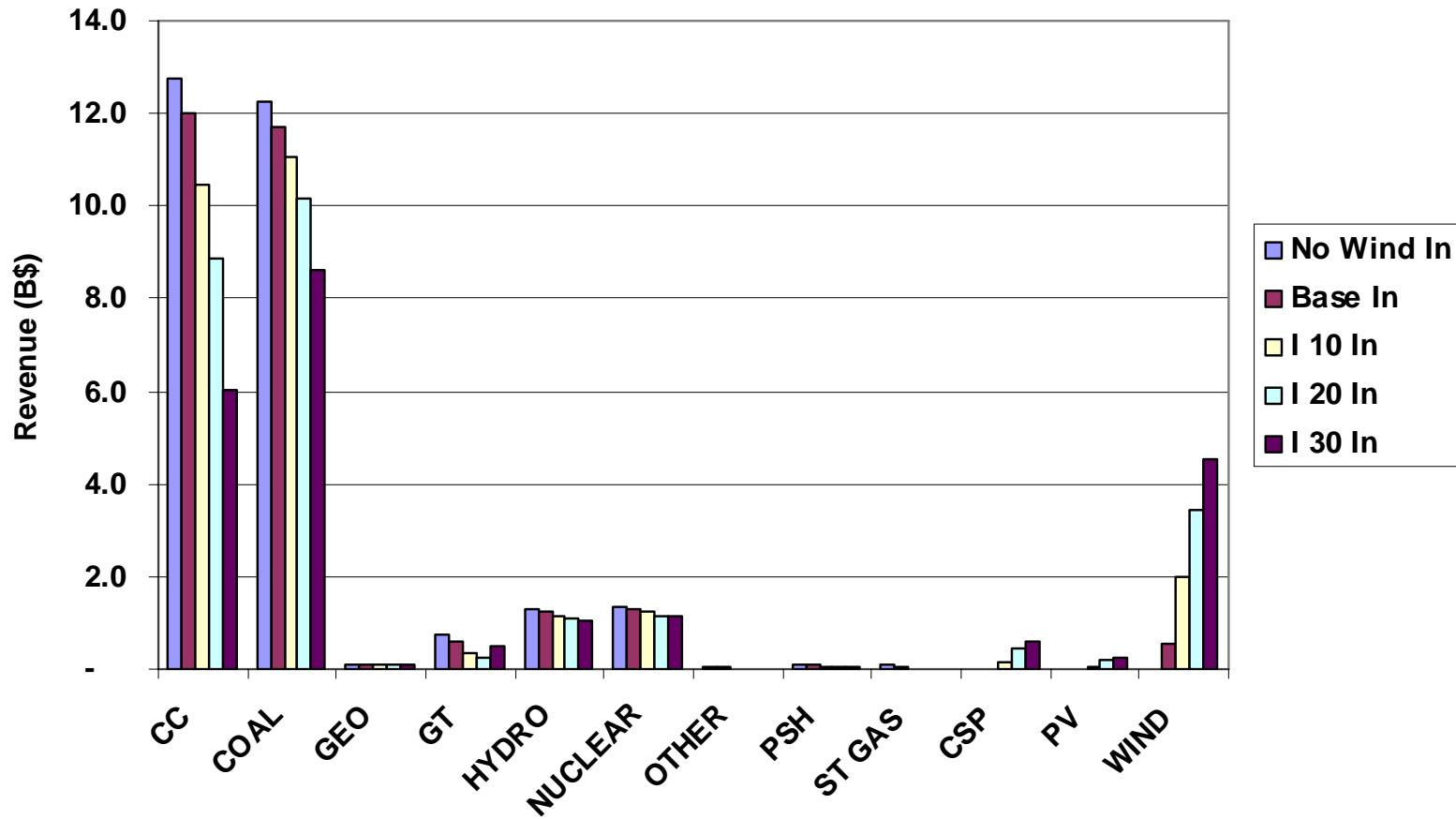


In Footprint Total Generation (GWh)



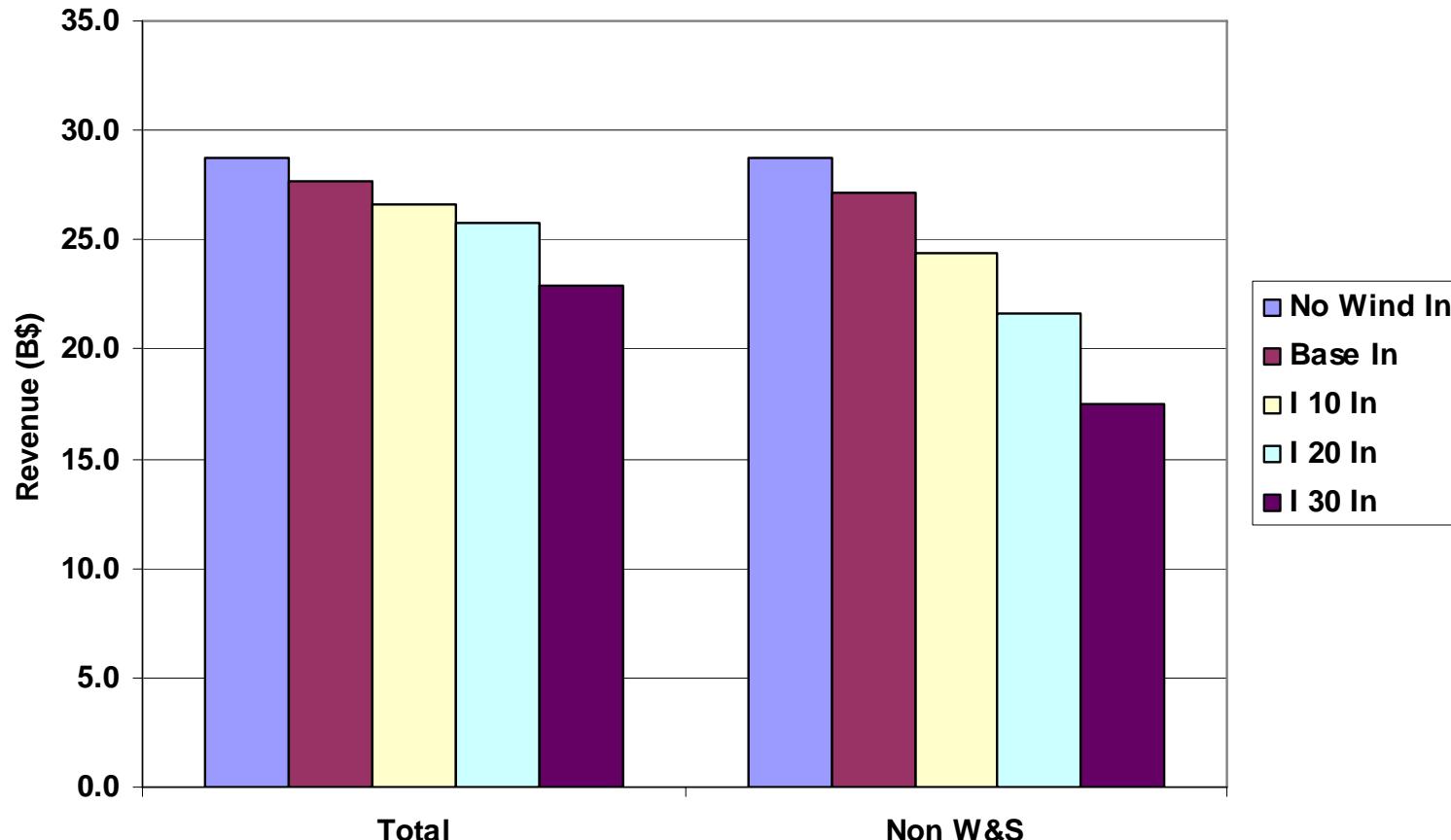
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In Footprint Revenue by Type (B\$)

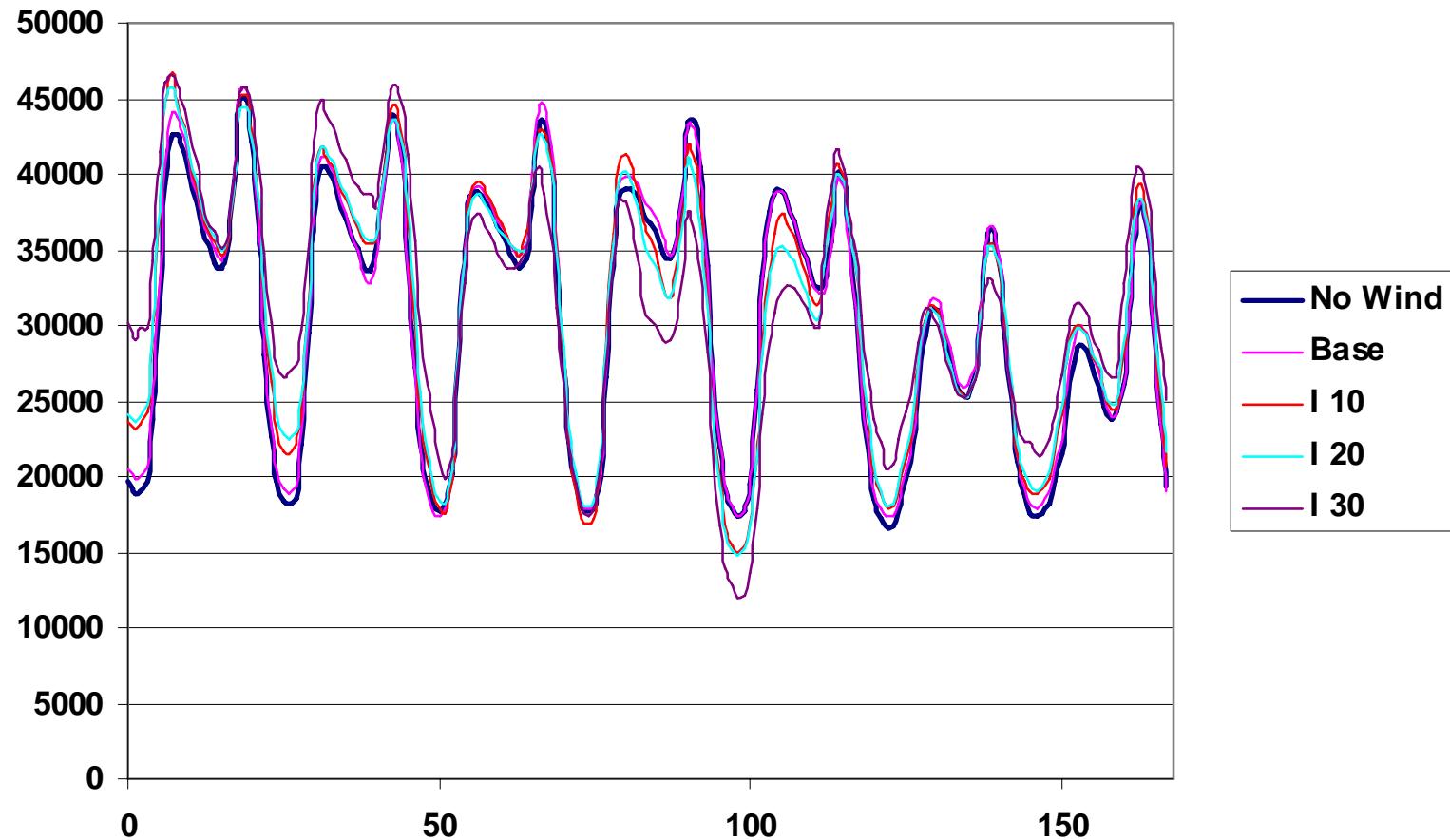


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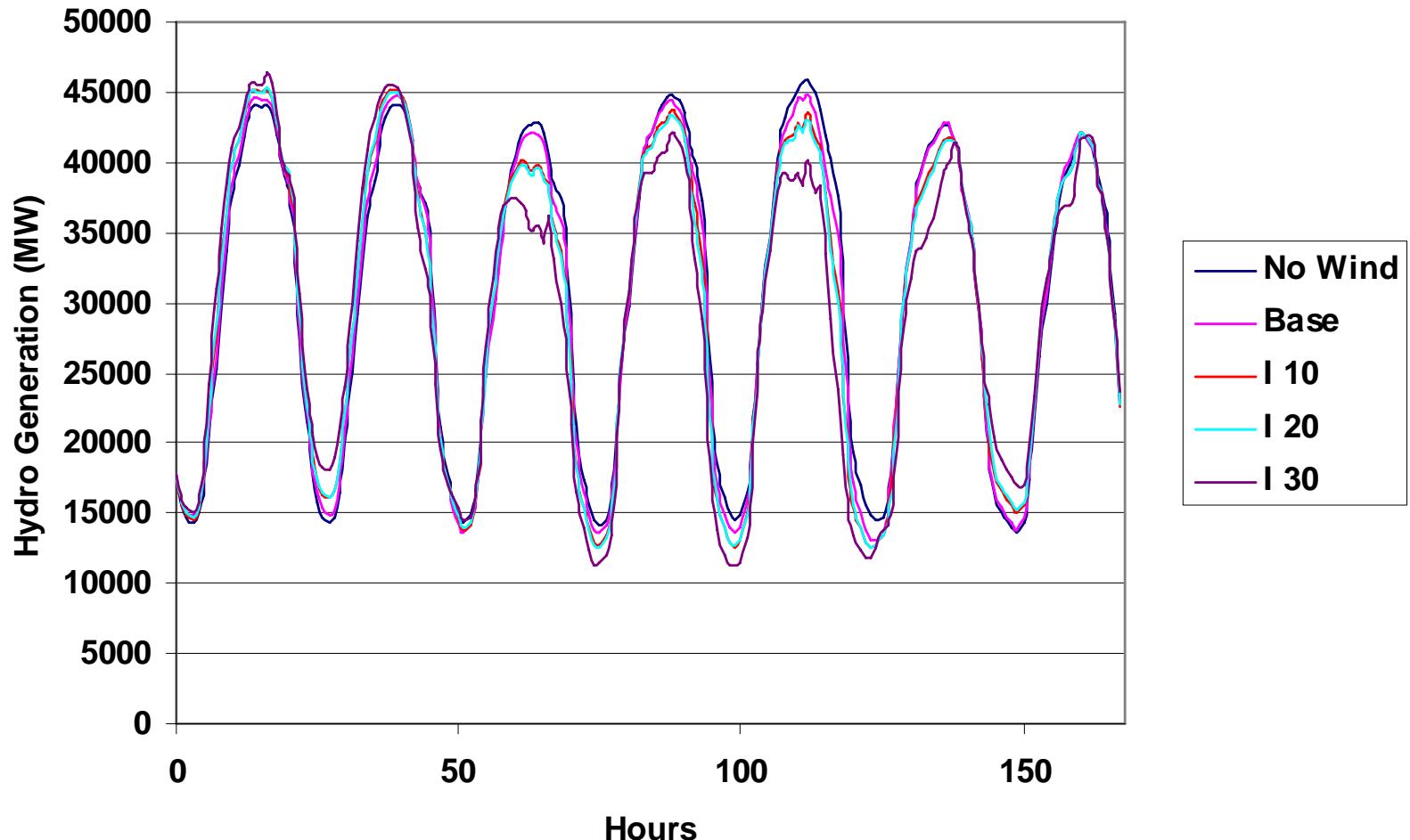


Hydro Operation – Week of March 13th

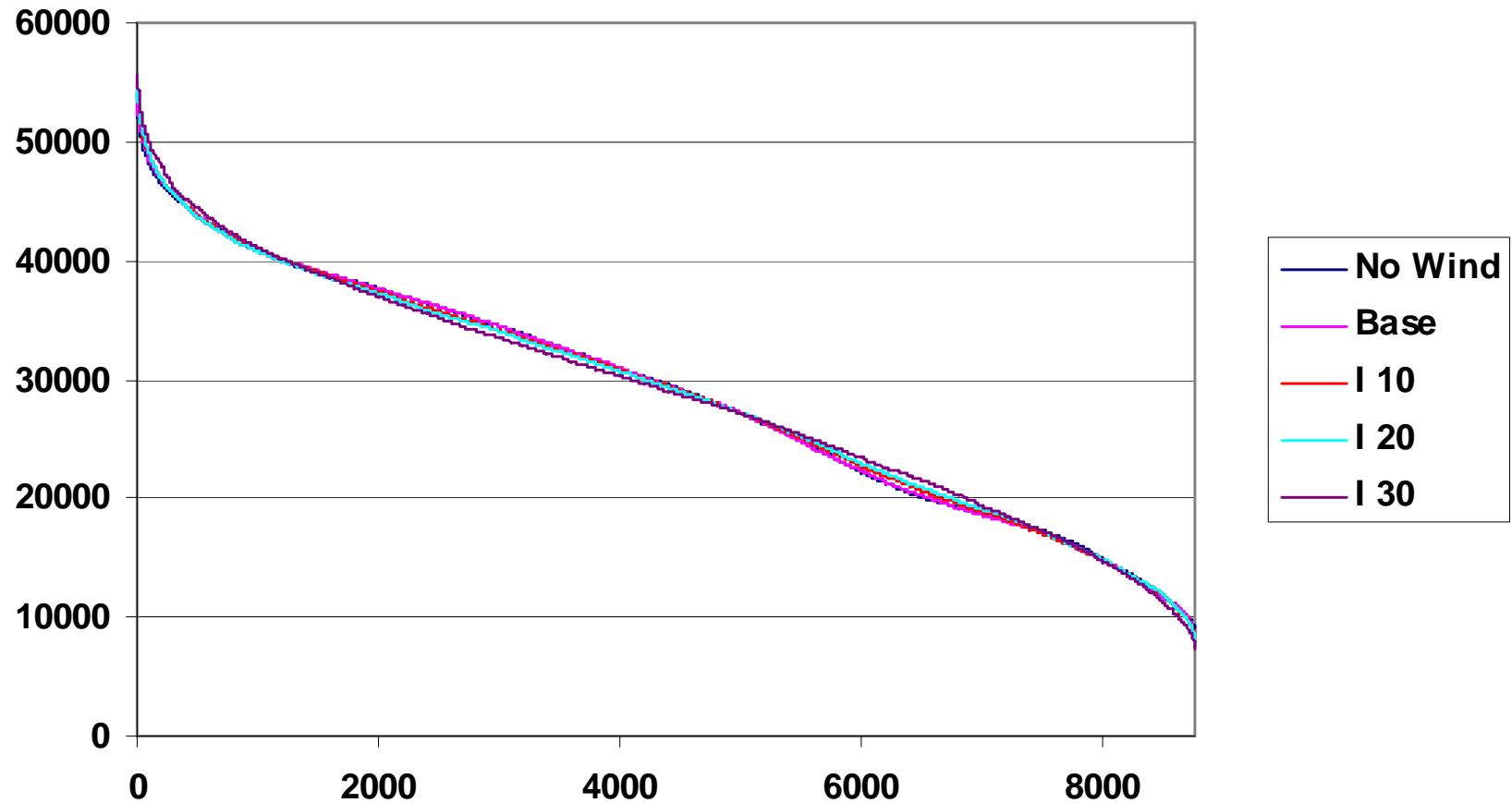


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Hydro Operation – Week of July 10th

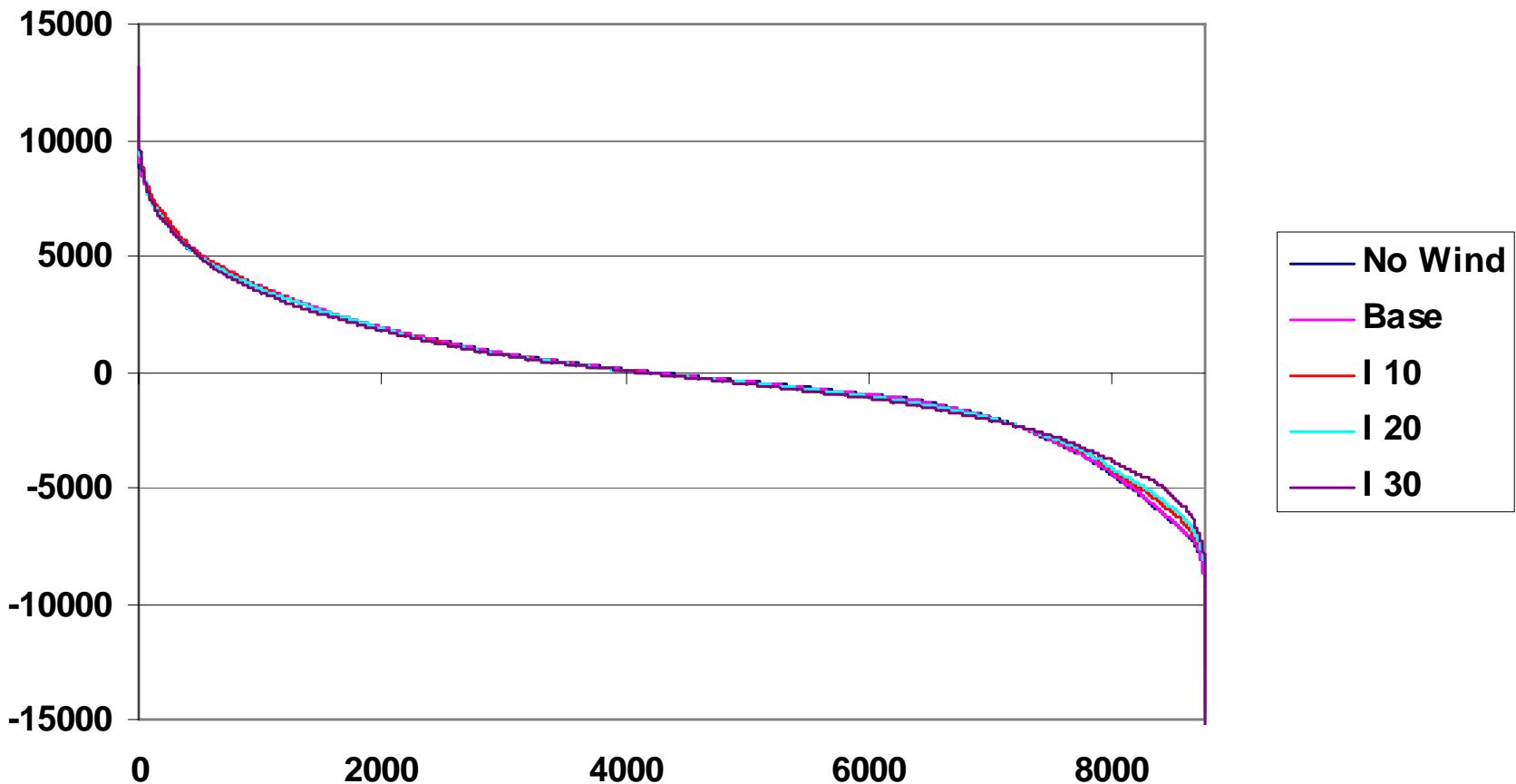


Annual Hydro Generation Duration Curve



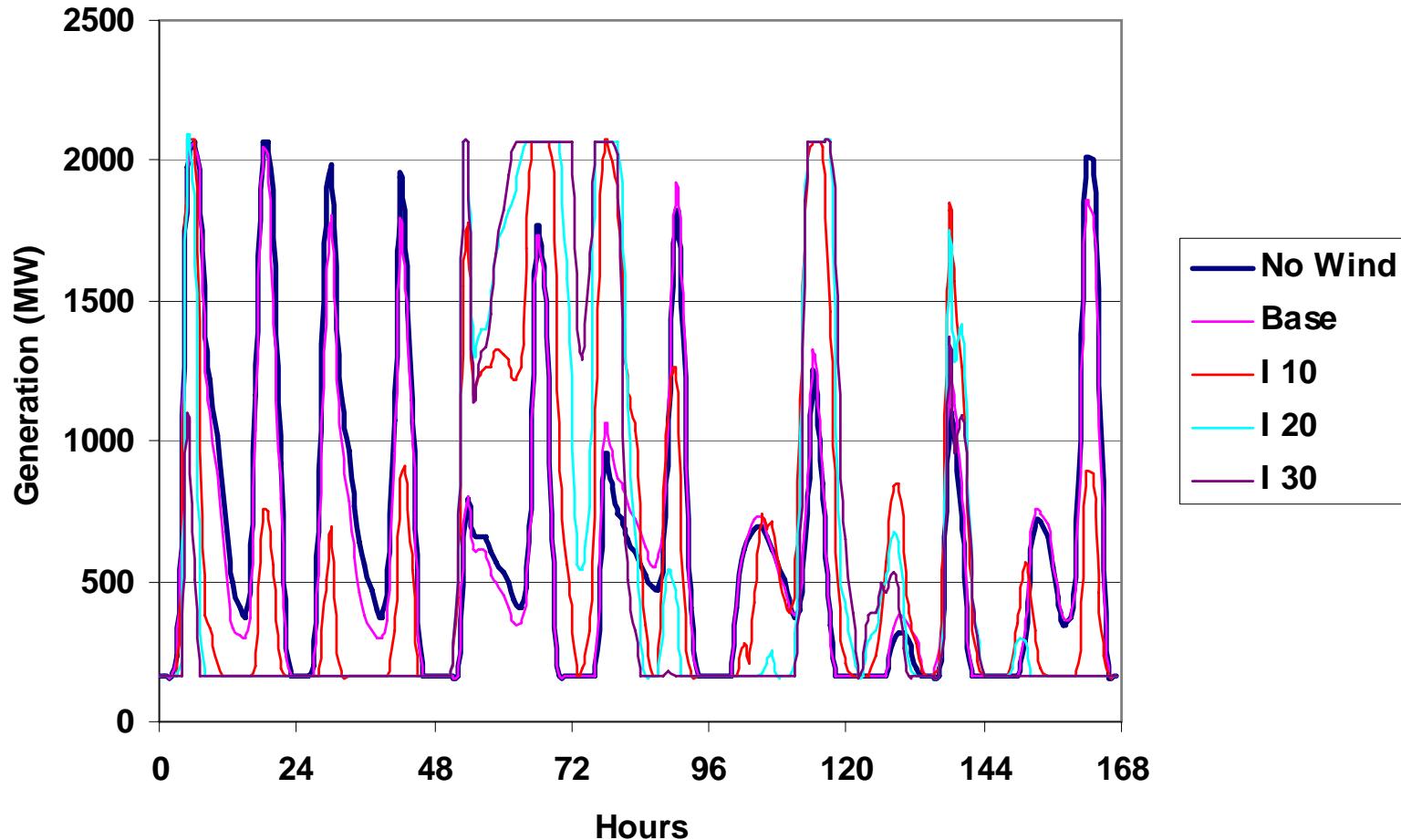
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Hourly Hydro Delta Duration Curve



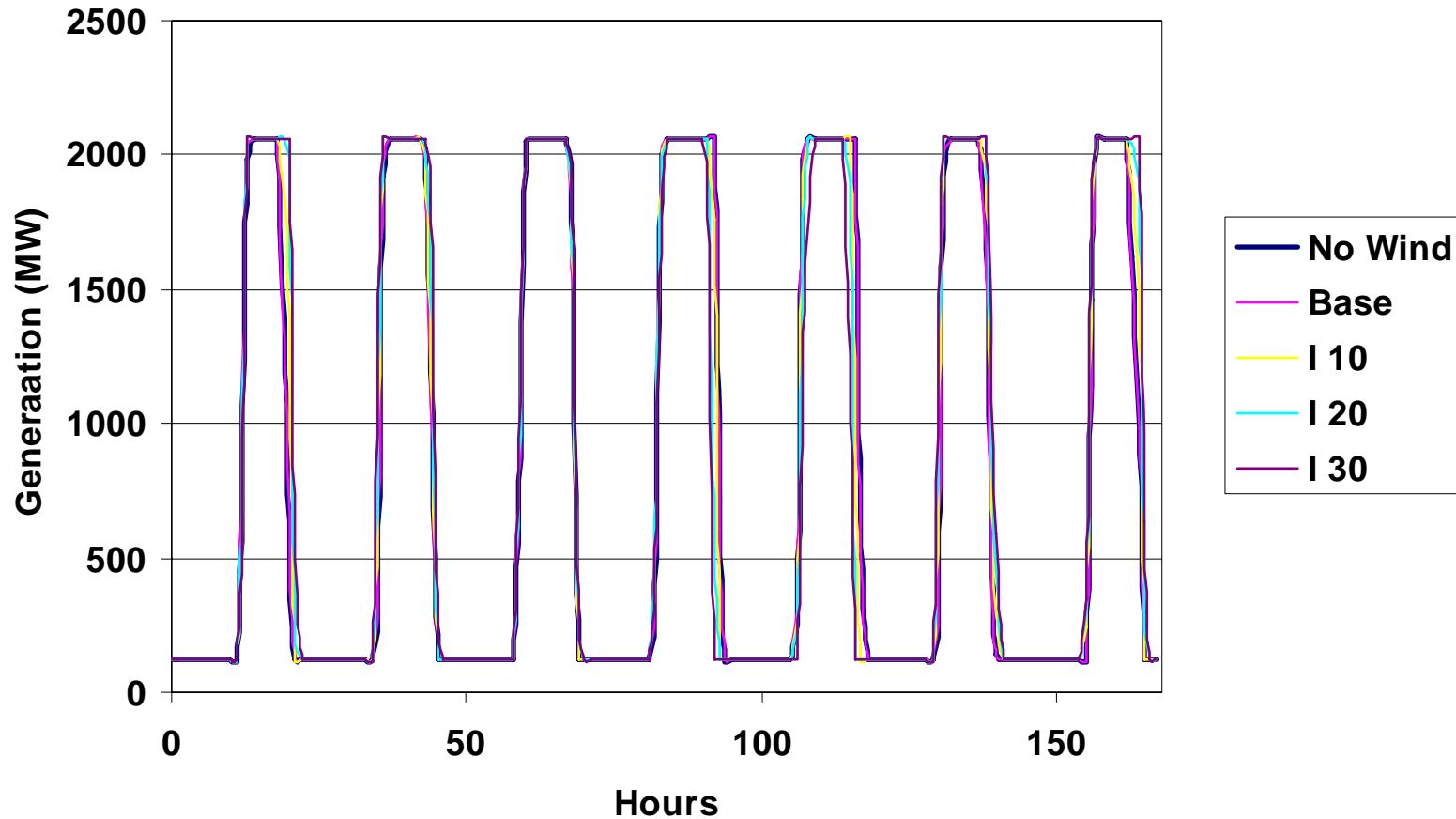
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Hoover Operation – Week of March 13th

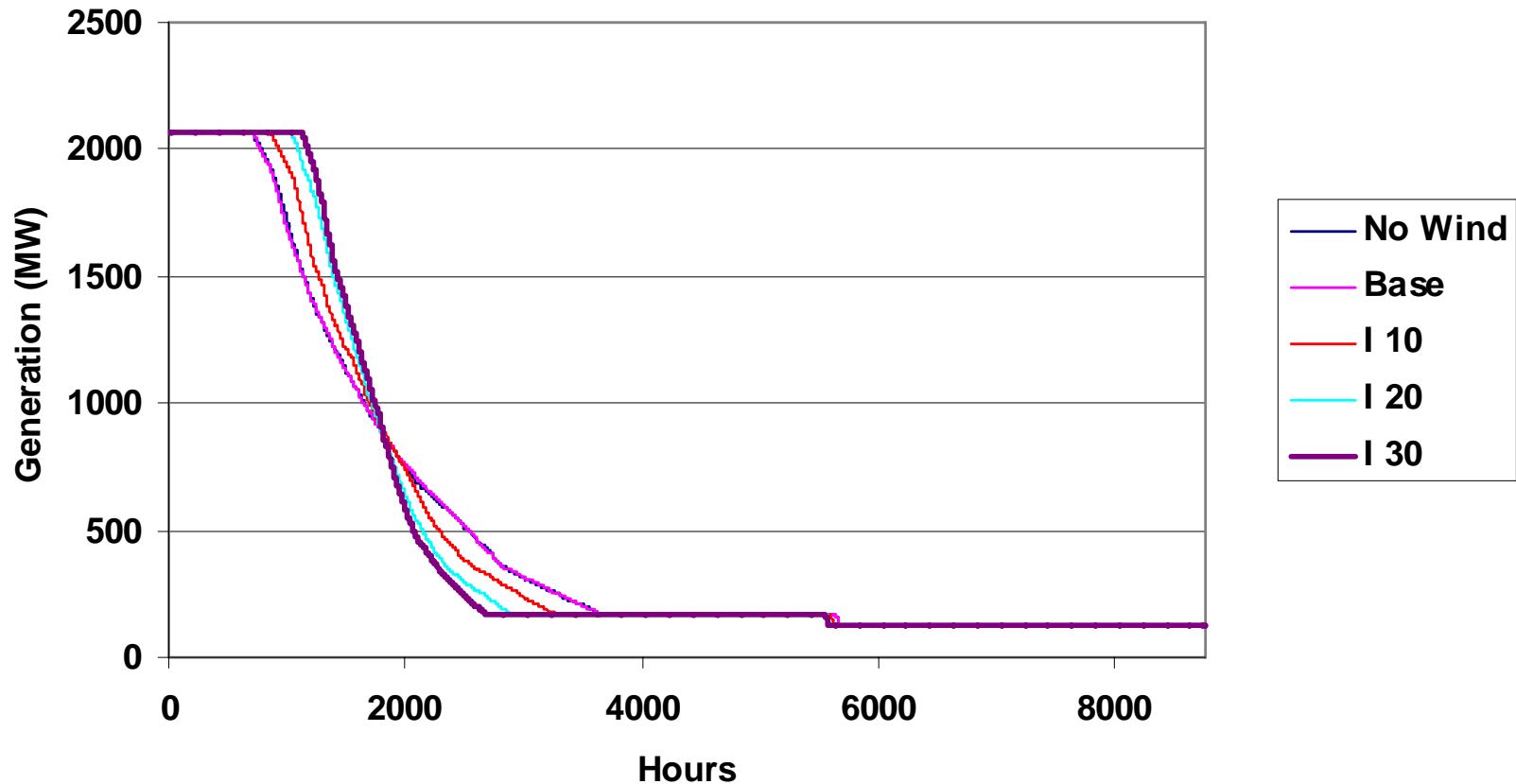


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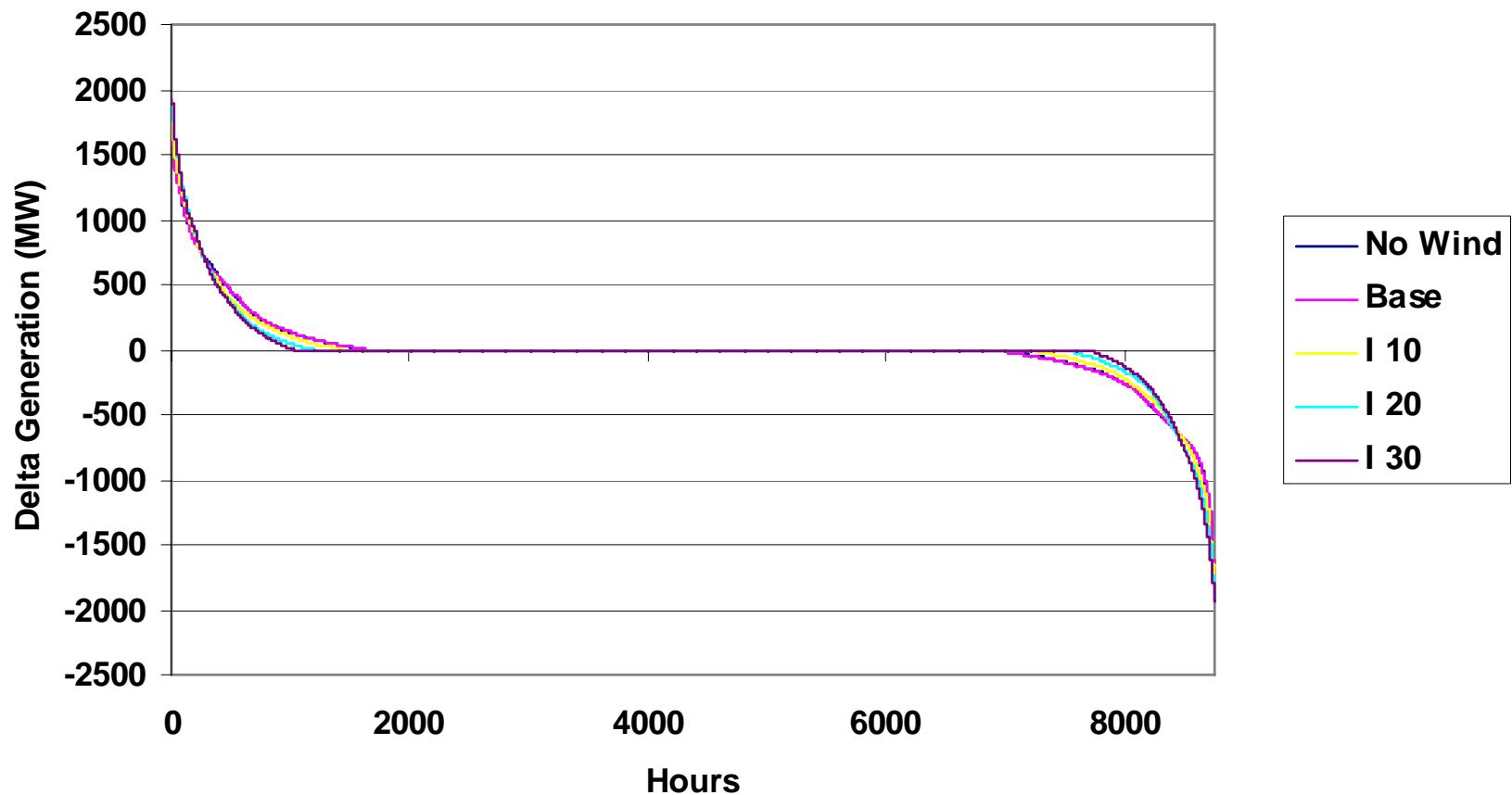
Hoover Operation – Week of July 10th



Hoover Annual Duration Curve



Hoover Hourly Delta Duration Curve



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Operational Summary

From a very high level, using “bubble” modeling of the transmission, energy penetrations up to 30% for wind and 5% for solar seems feasible.



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