GE
Energy

Western Wind & Solar Integration Study

Operational Impacts Part 2

Gary Jordan

Stakeholder Meeting
July 30, 2009

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Operational Analysis (continued)

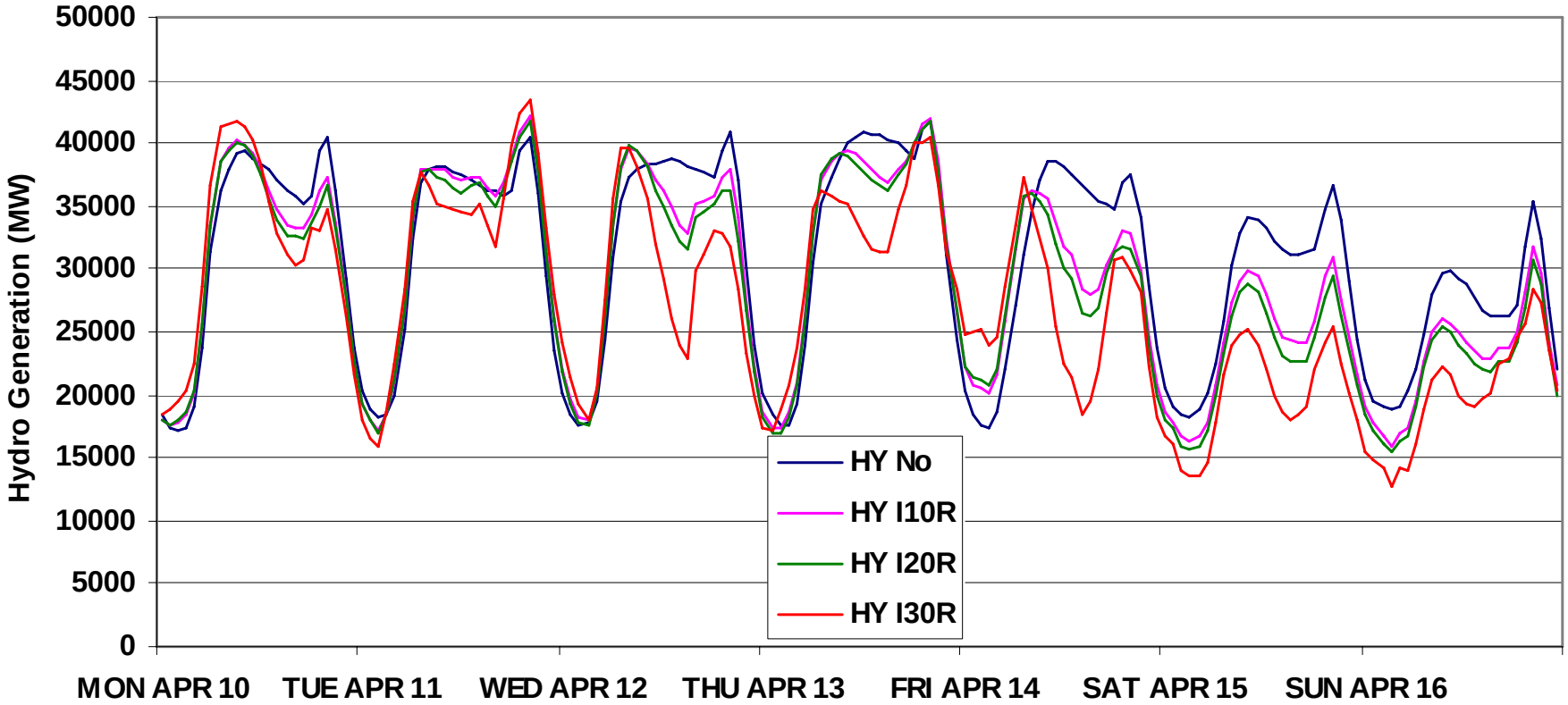
- Conventional Hydro Operation
- Pumped Storage Hydro Operation
- Fuel Price Sensitivity
- Transmission flows
- Transmission Sensitivity

Reliability Analysis

Hydro Operation

- Base cases had hydro scheduled after forecasted wind and solar.
- Hydro schedule variation with increasing renewable penetration.
- Economic impact of NOT rescheduling the hydro based on Renewable forecasts.
- Pumped Storage Hydro operation

Hydro Operation - Week of April 10th



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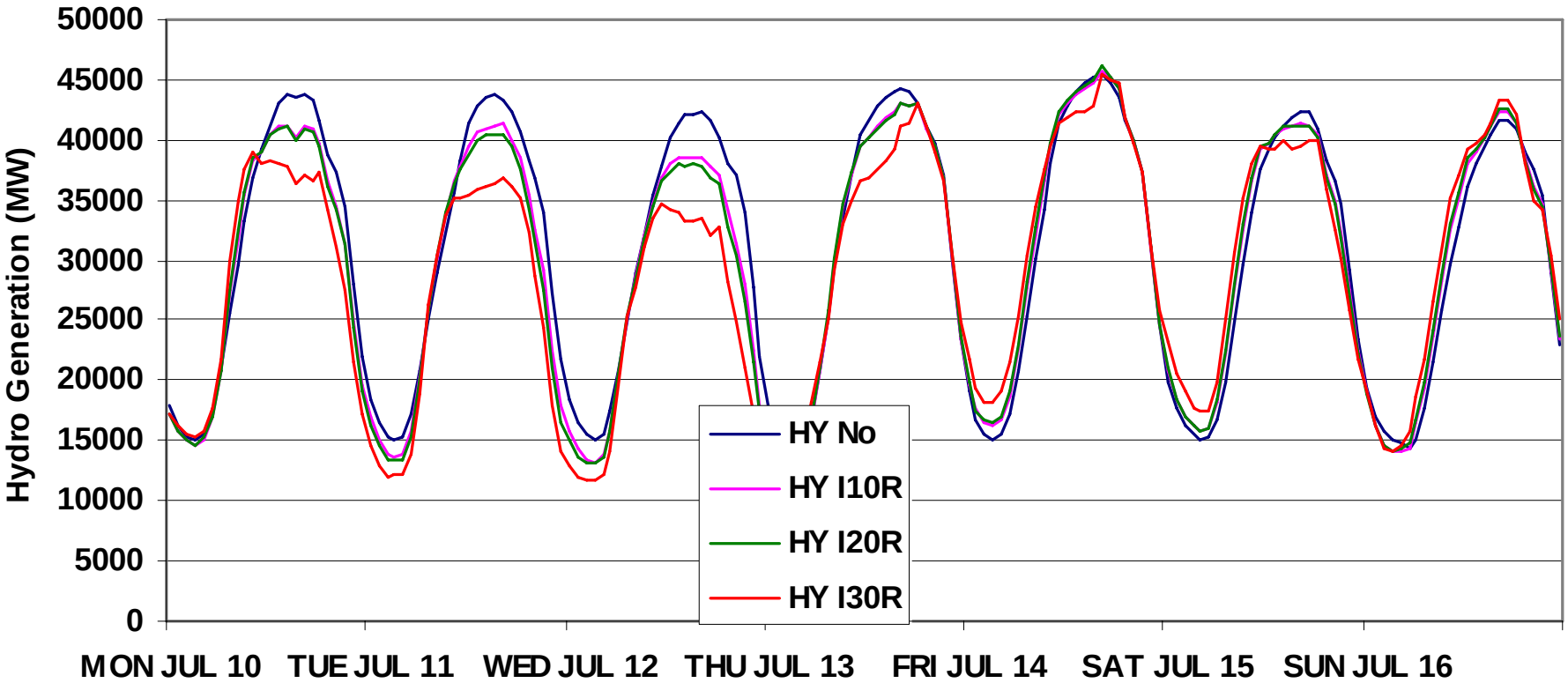
Hydro Operation - Week of July 10th



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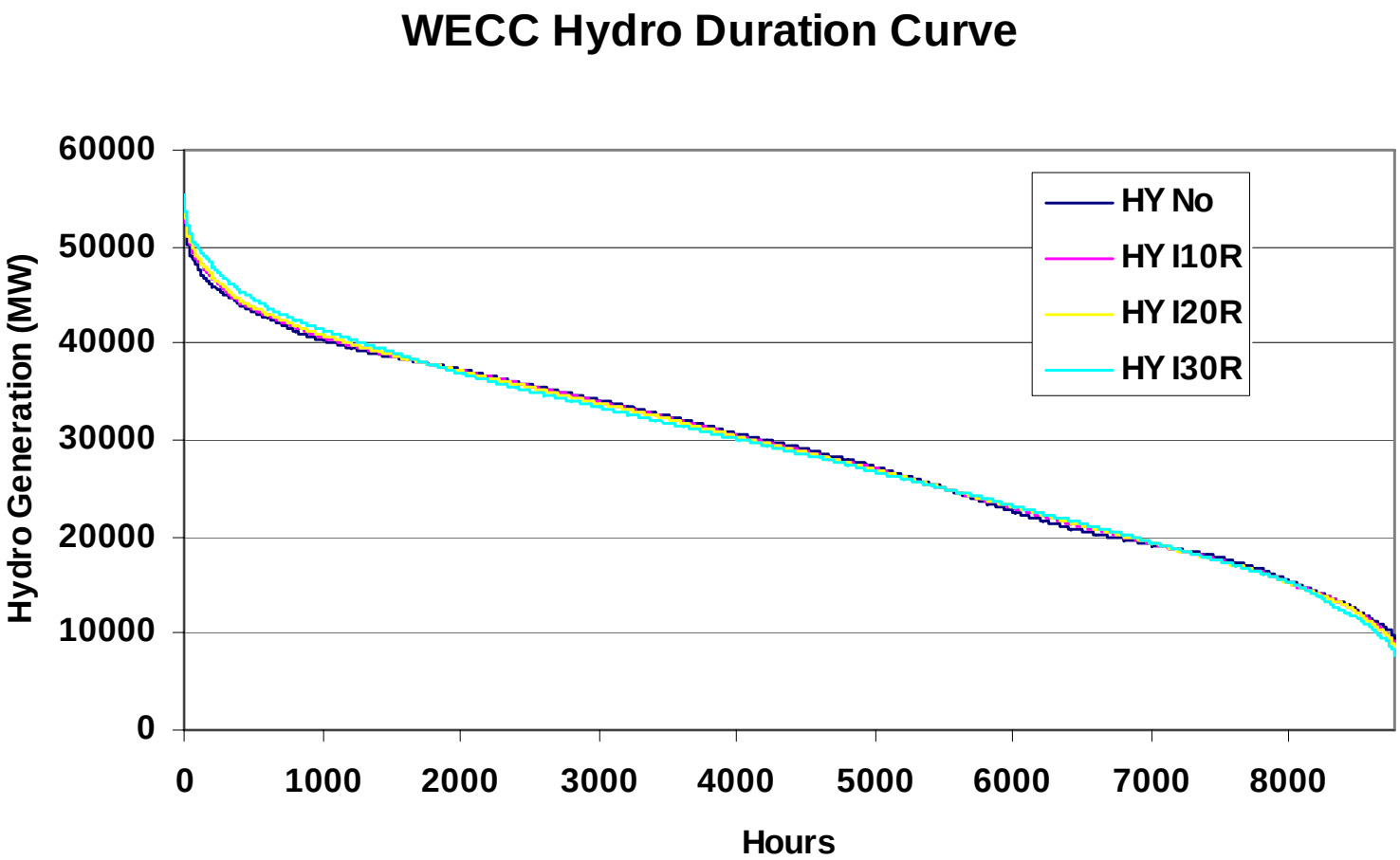

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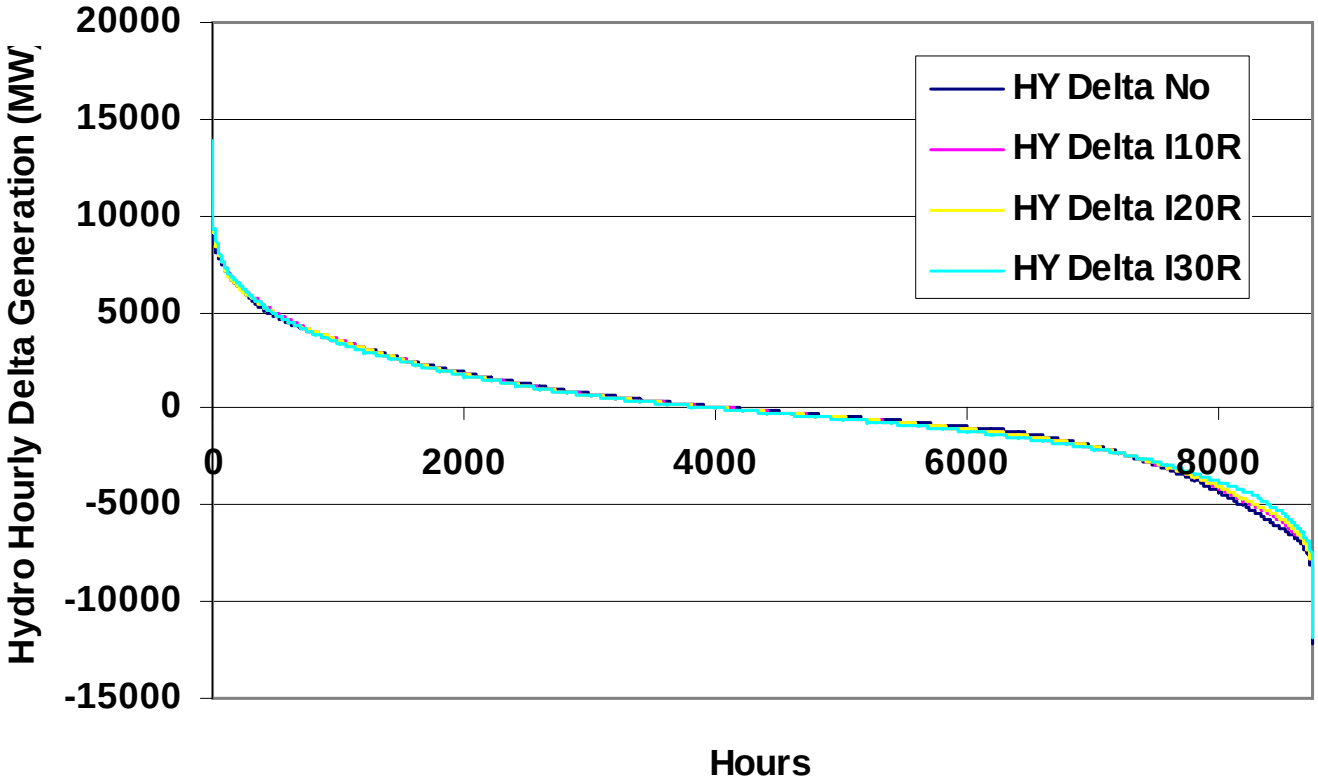
WECC Hydro Hourly Delta Duration Curve



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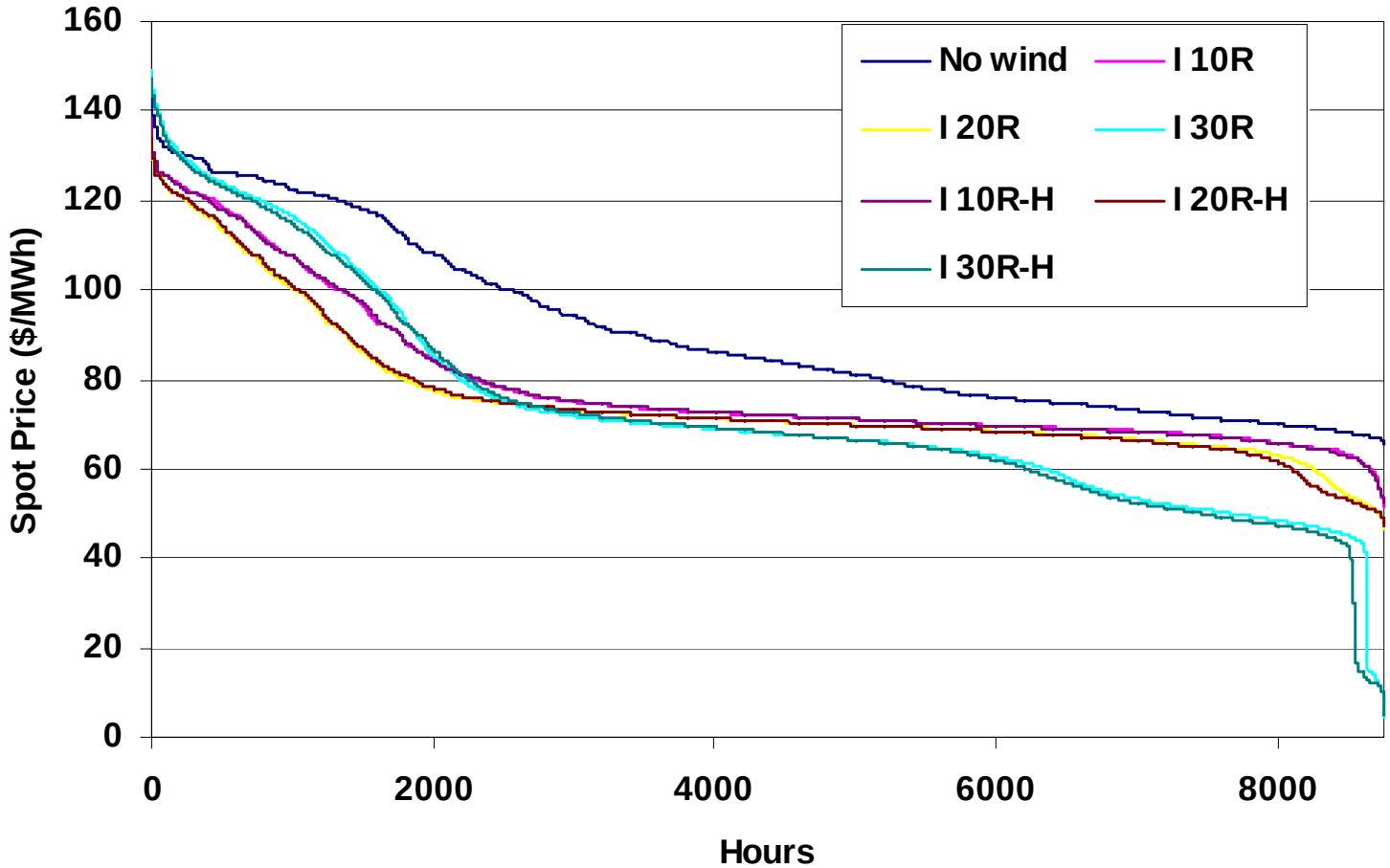
Spot Price Impact of Hydro Dispatch



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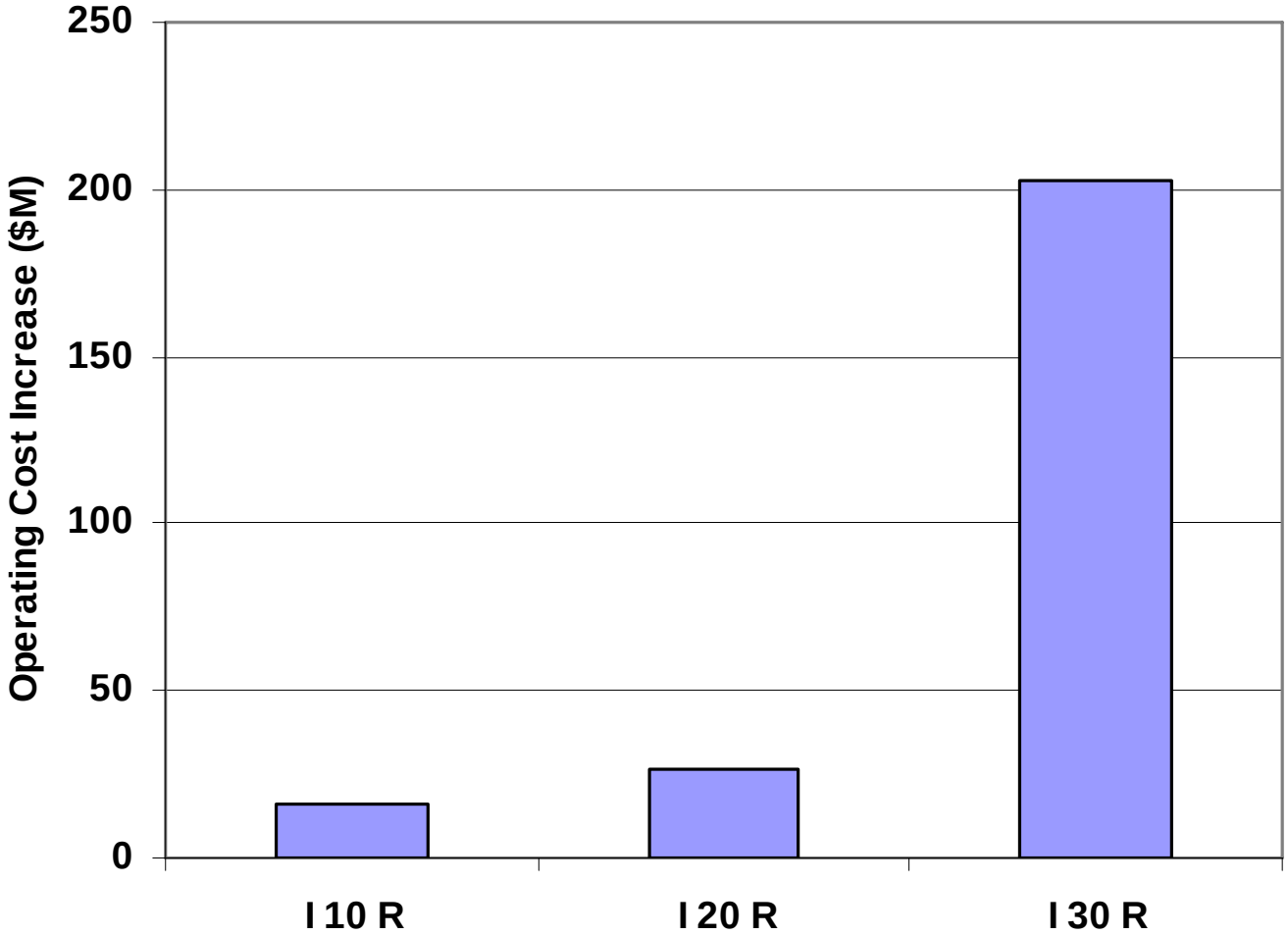
WECC Operating Cost Increase for Not Shifting Hydro



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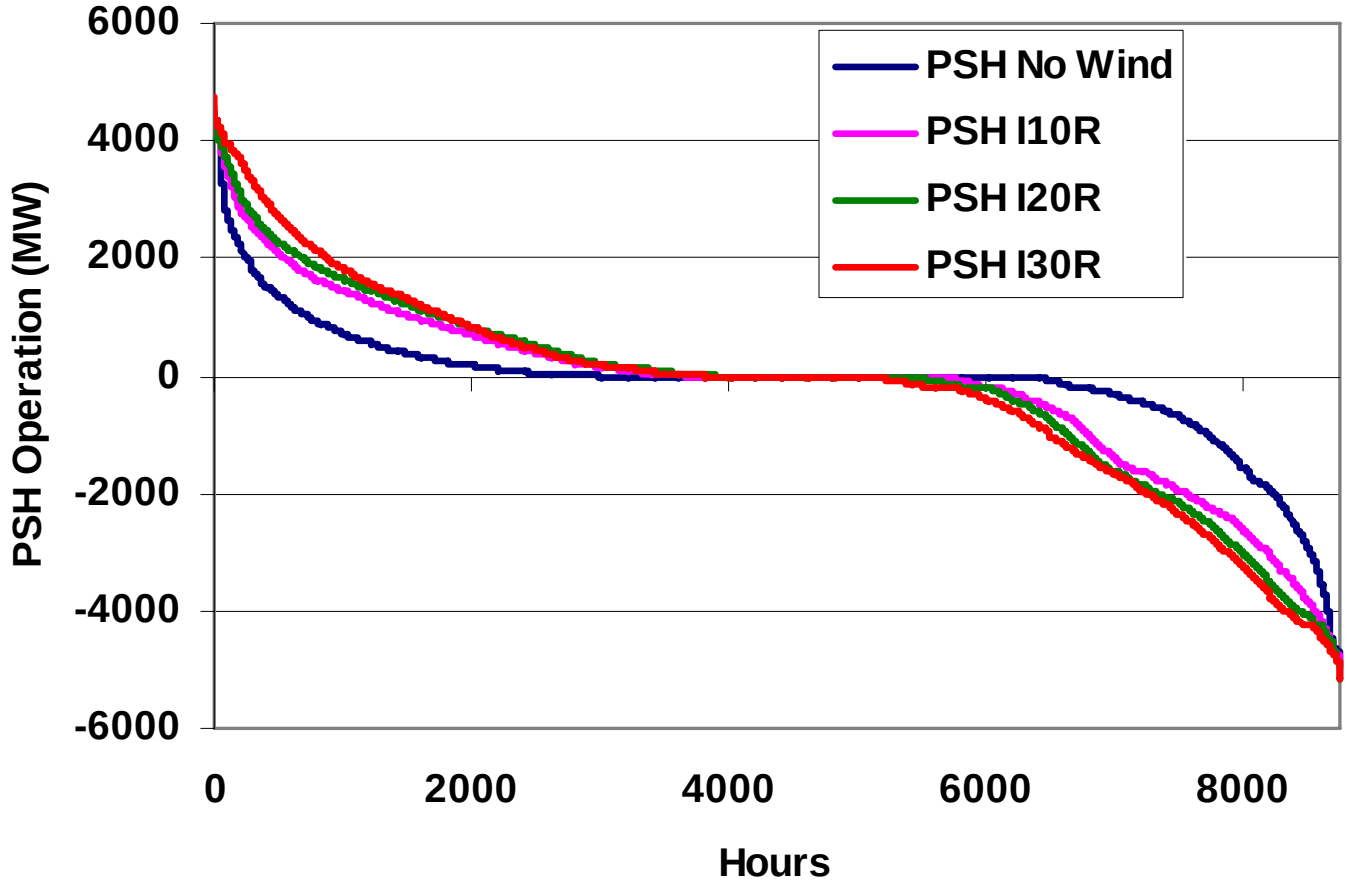
PSH Annual Duration Curve



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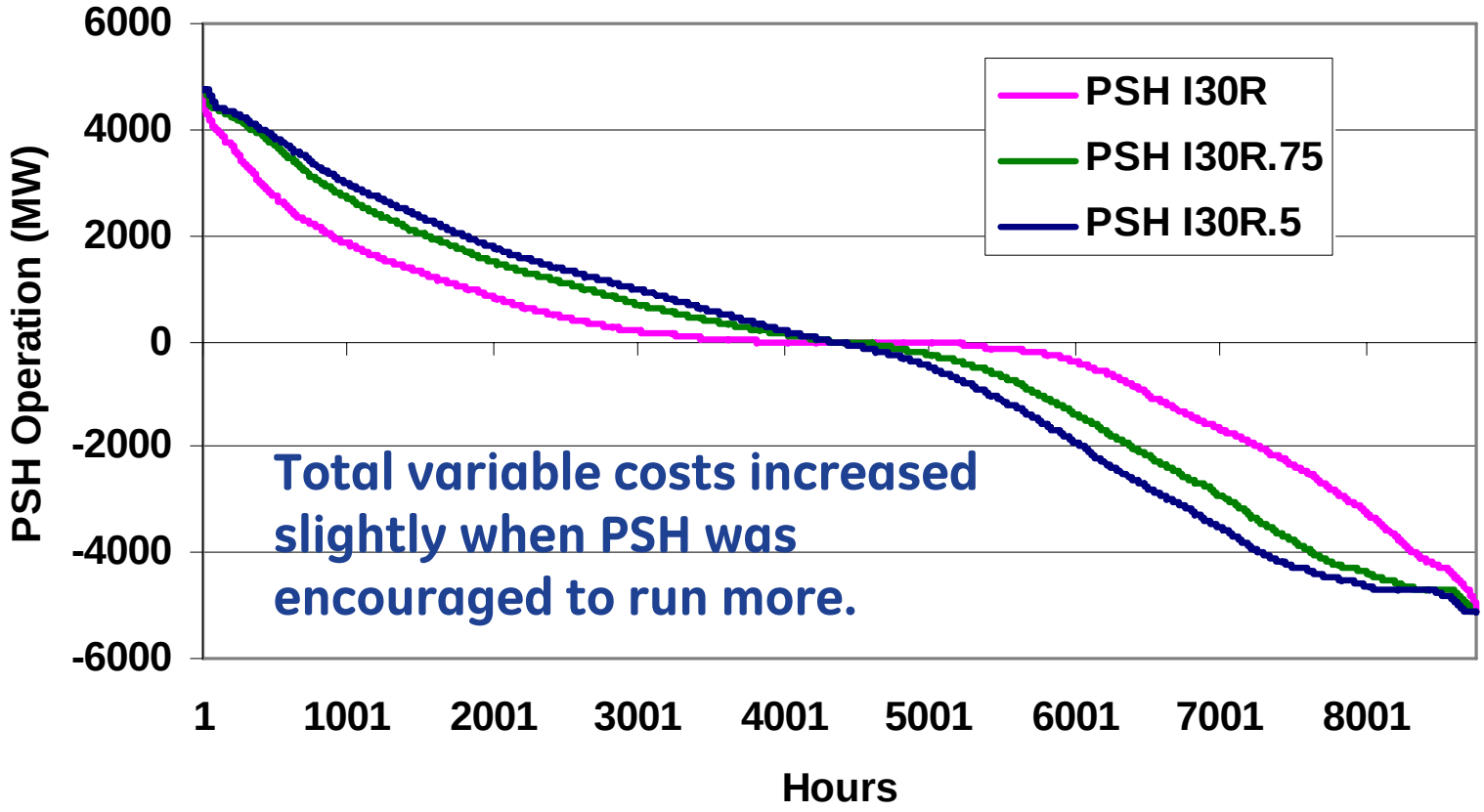
PSH Operation with discounted Pumping Costs



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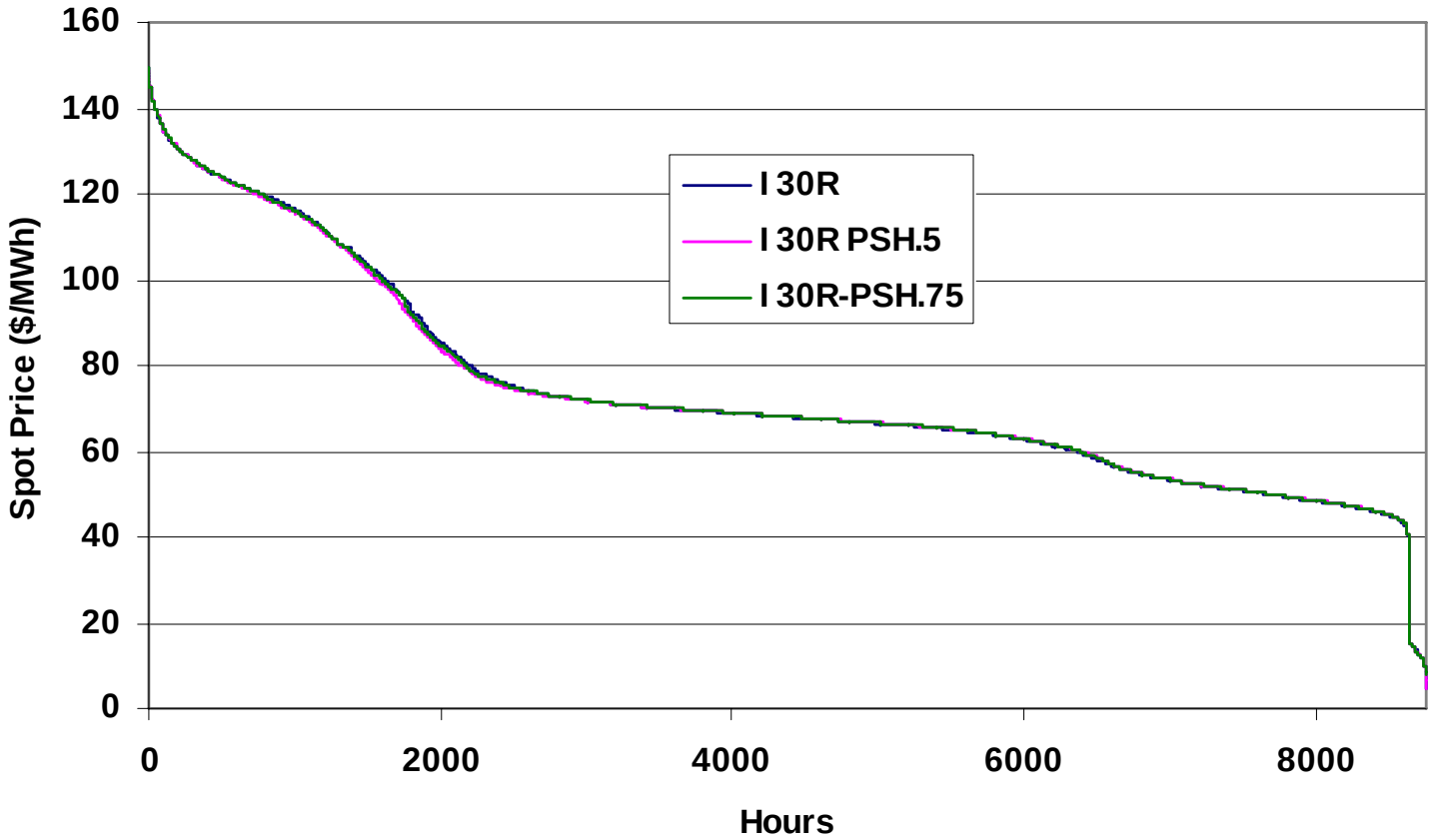
Annual Spot Price Duration Curve



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Gas Price Sensitivity

The 2009 Natural Gas Glut: Implications for Coal and Power Markets

Prepared for

2009 Eastern Fuel Buyers Conference

Prepared by

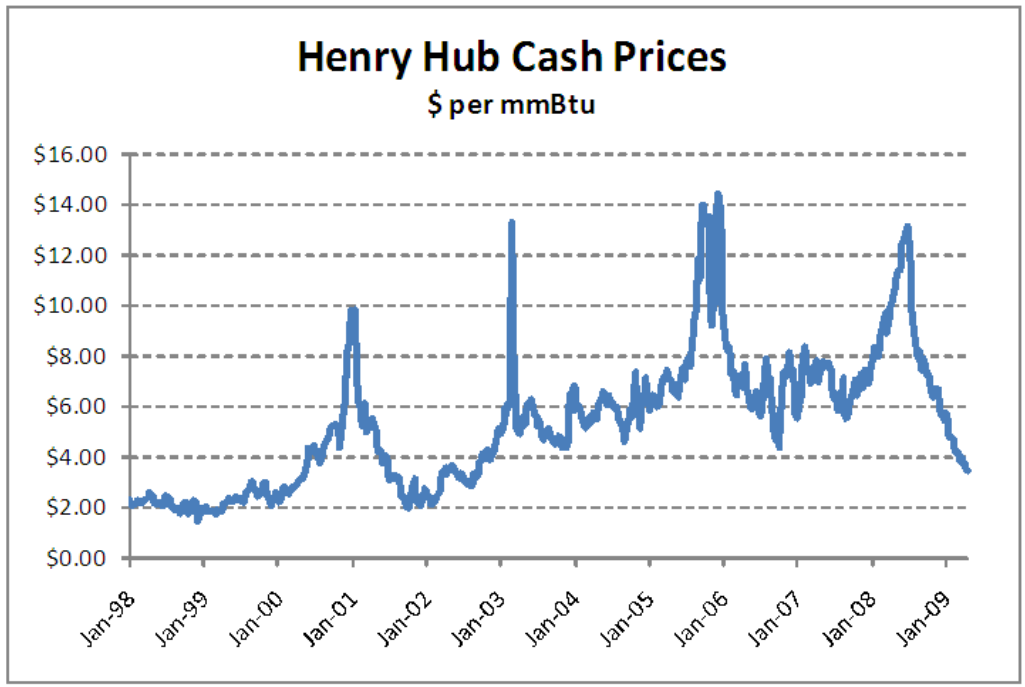
Seth Schwartz

Energy Ventures Analysis, Inc.

May 2009

The Natural Gas Glut: What the Heck Happened?

- Natural gas prices hit a high of $13 per mmBtu in July 2008
- Prices fell to $3.50 per mmBtu by the end of April 2009



Energy Ventures Analysis, Inc.

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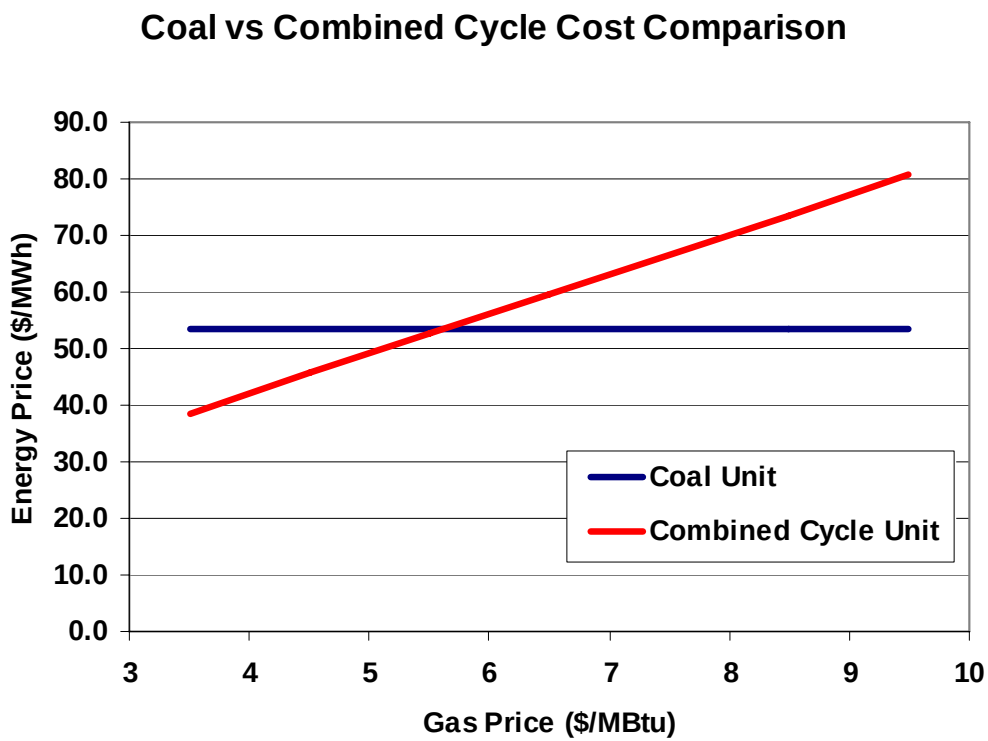
Coal vs Combined Cycle Tradeoff

- Base assumed $30/ton CO2 costs
- Each $/ton for CO2 adds
  - $0.60/MWh to Combined Cycle
  - $1.00/MWh to Coal Unit



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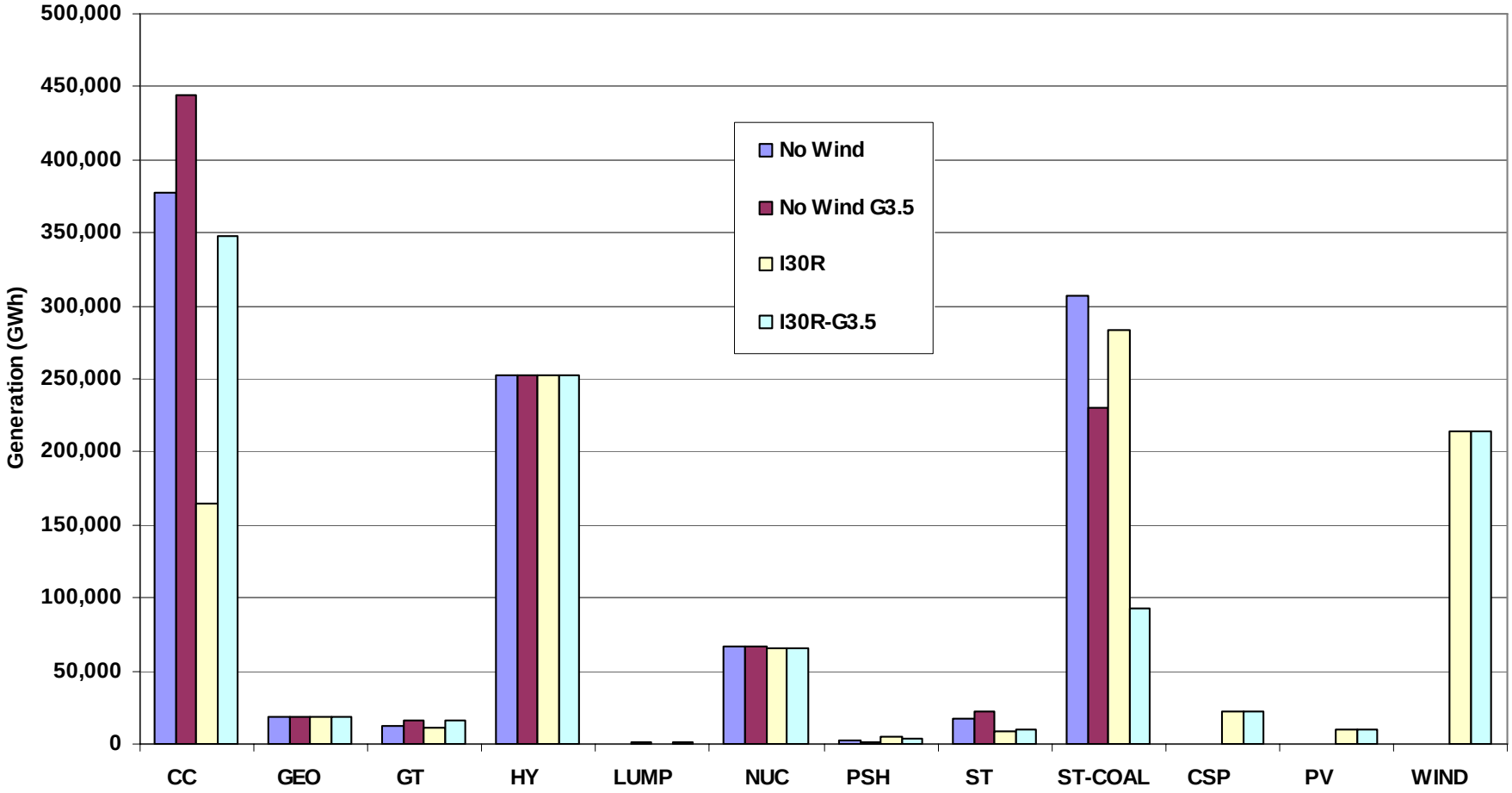
WECC Generation by Type with Gas Price Reductions



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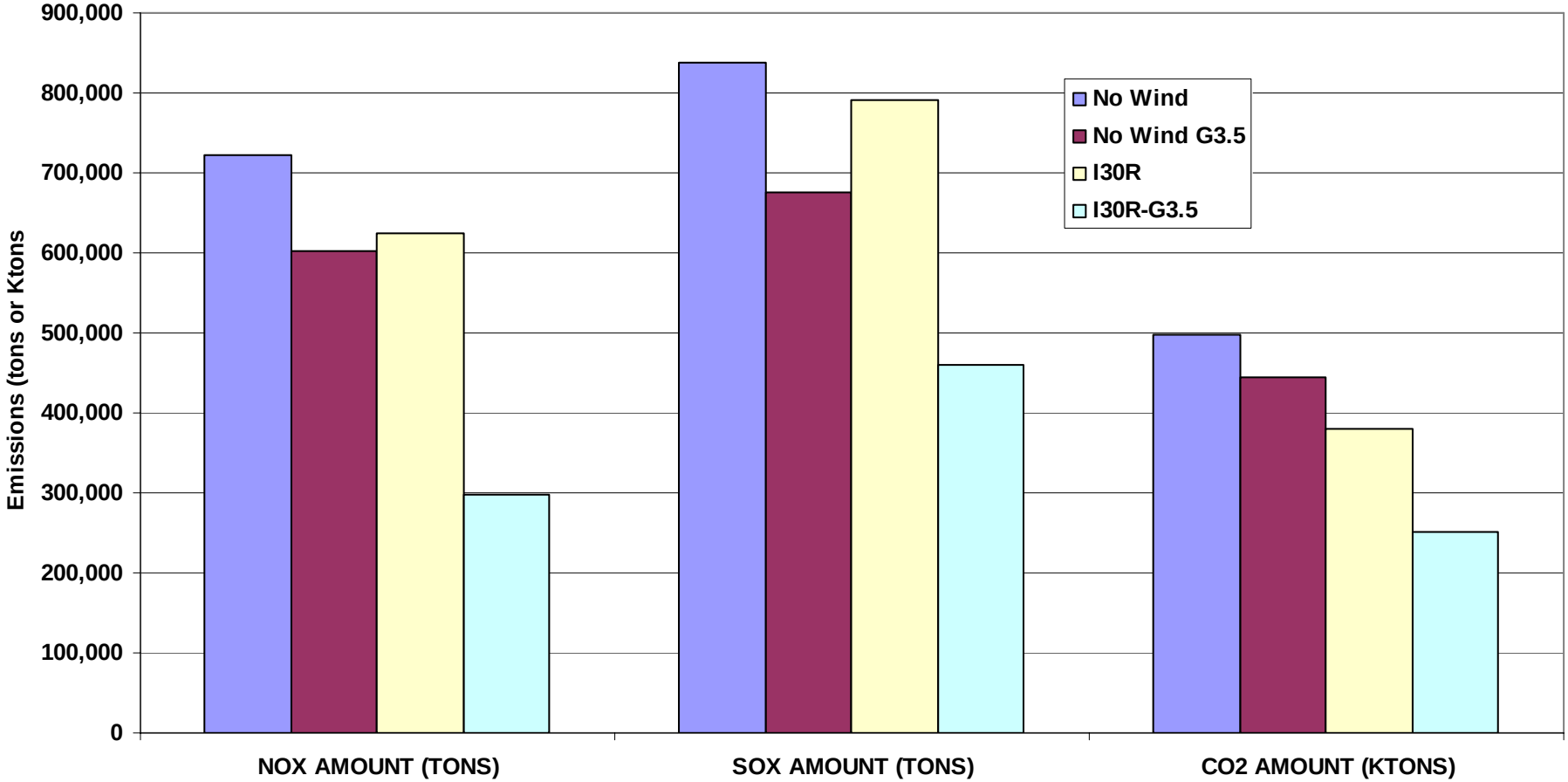
Total WECC Emissions with Gas Price Reductions



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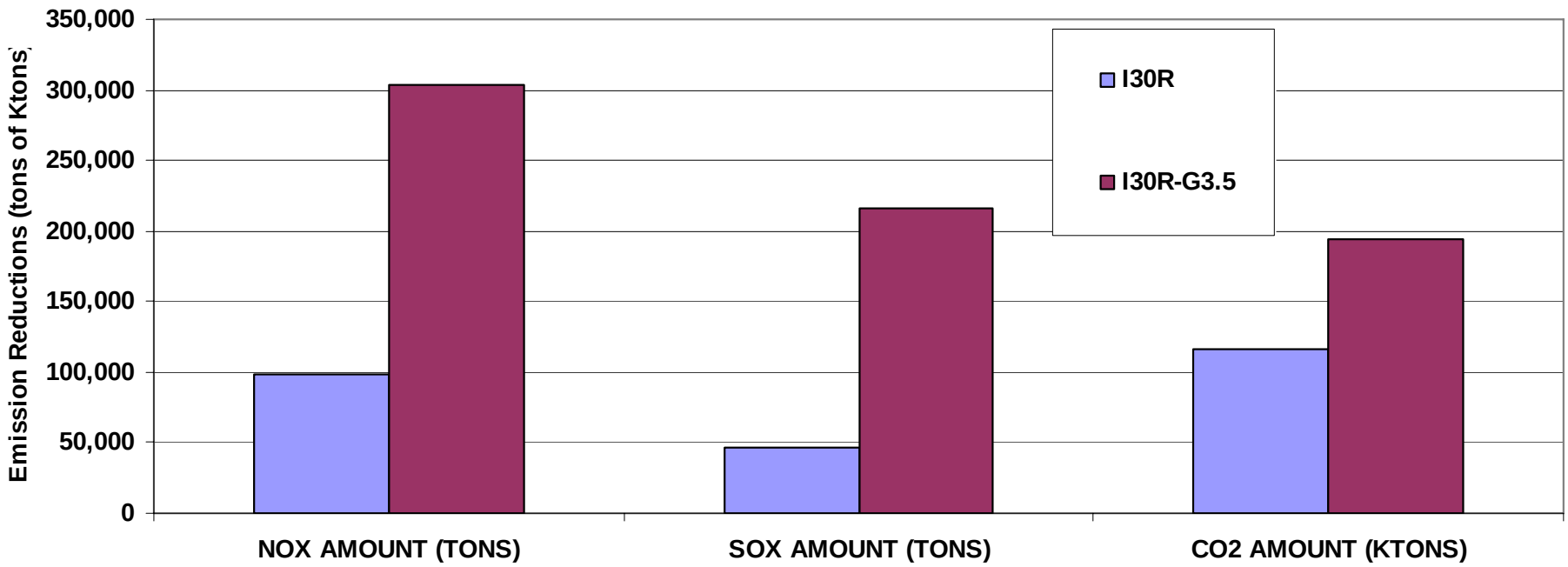
WECC Emission Reductions with Gas Price Reductions



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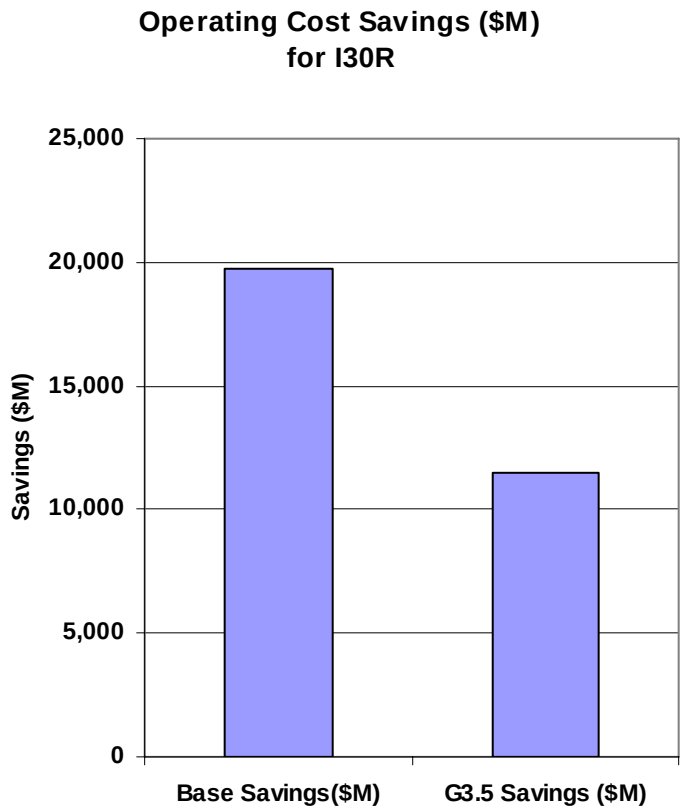
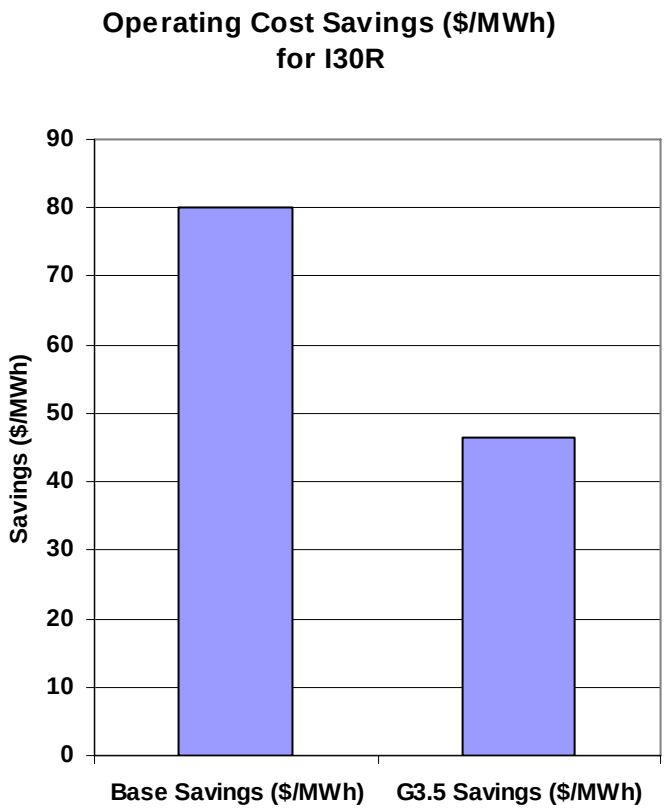
Operating Cost Savings for I30R vs No Wind Case





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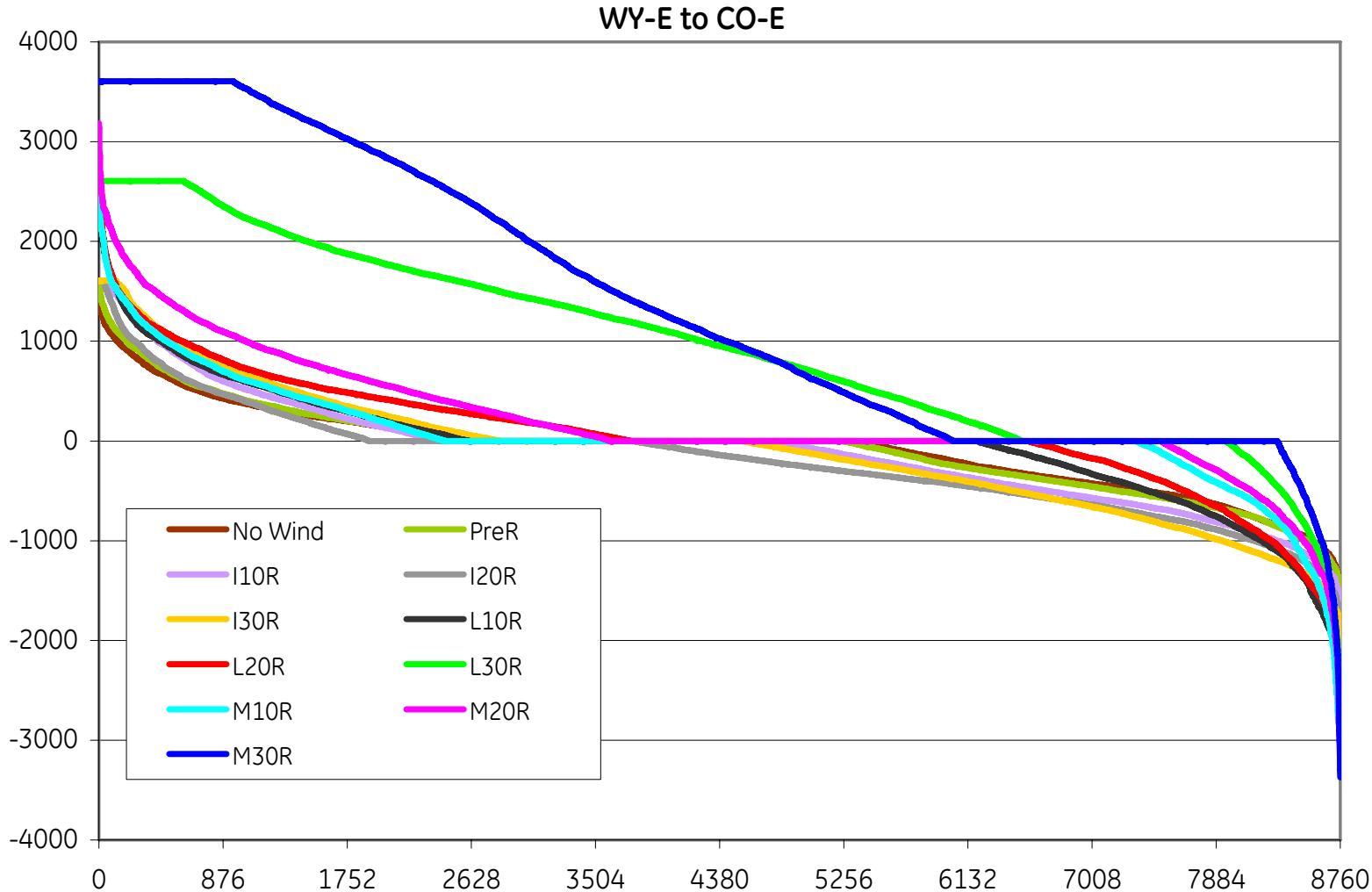
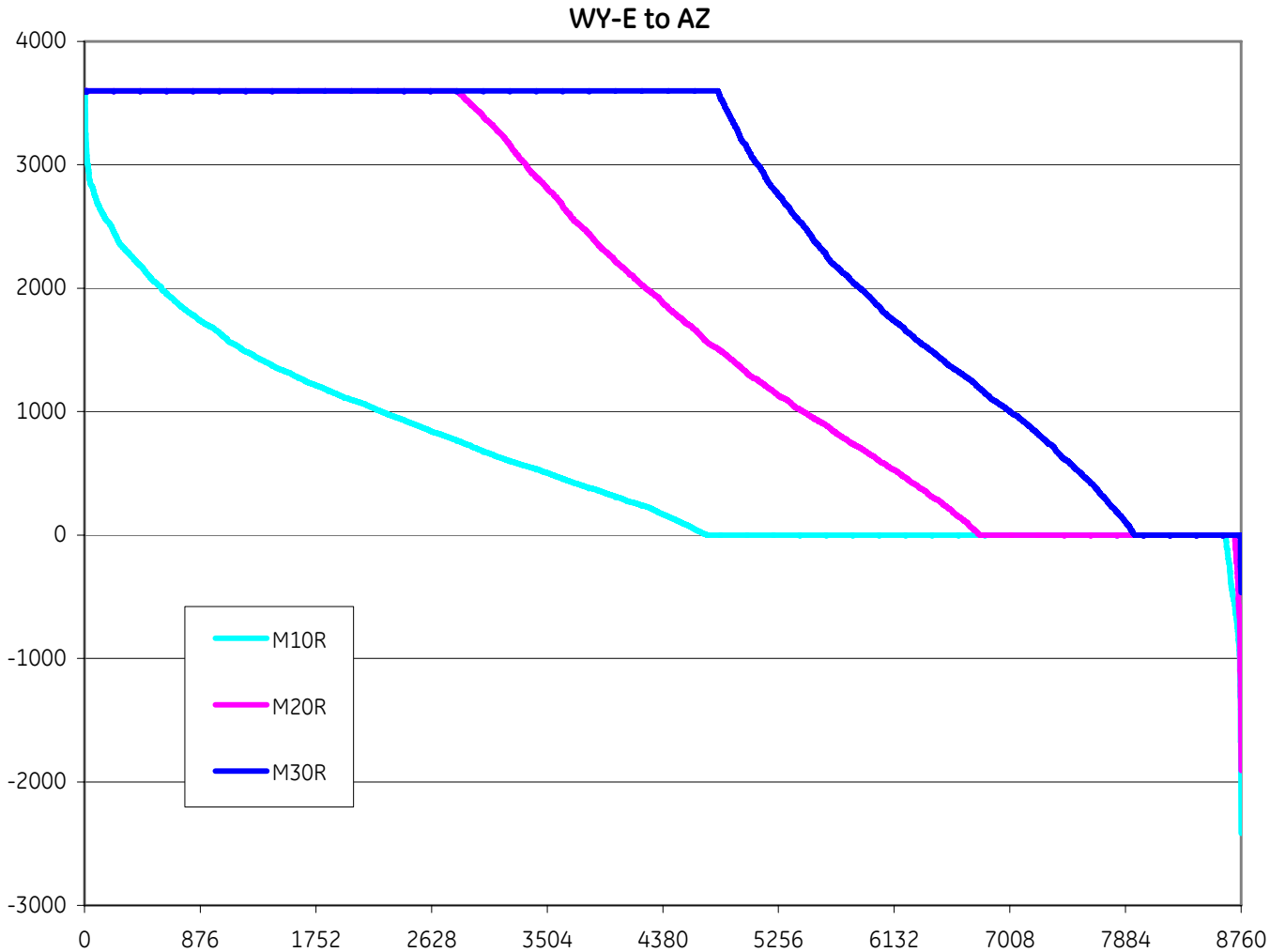
Bubble MAPS Transmission Path Flows

- by Path
- by Scenario



	No Wind	PreR	I10R	I20R	I30R	L10R	L20R	L30R	M10R	M20R	M30R
Max	1605	1605	1605	1605	1605	2605	2605	2605	3605	3605	3605
# hrs at Max	0	4	58	29	120	1	5	598	0	0	950
# hrs Pos	2599	2674	2451	1903	2827	2608	3747	6506	2438	3604	6026
# hrs Neg	3432	3518	3965	4987	4231	2573	2205	814	1451	1270	446
CF Abs	18	20	25	26	30	14	15	41	8	11	40
CF	-5	-5	-6	-12	-7	-1	3	37	2	6	37
Avg	-72	-74	-96	-196	-105	-21	79	953	62	218	1351

imagination at work



	M10R	M20R	M30R
Max	3600	3600	3600
# hrs at Max	5	2820	4797
# hrs Pos	4717	6782	7952
# hrs Neg	118	48	5
CF Abs	16	53	71
CF	16	53	71
Avg	567	1892	2552

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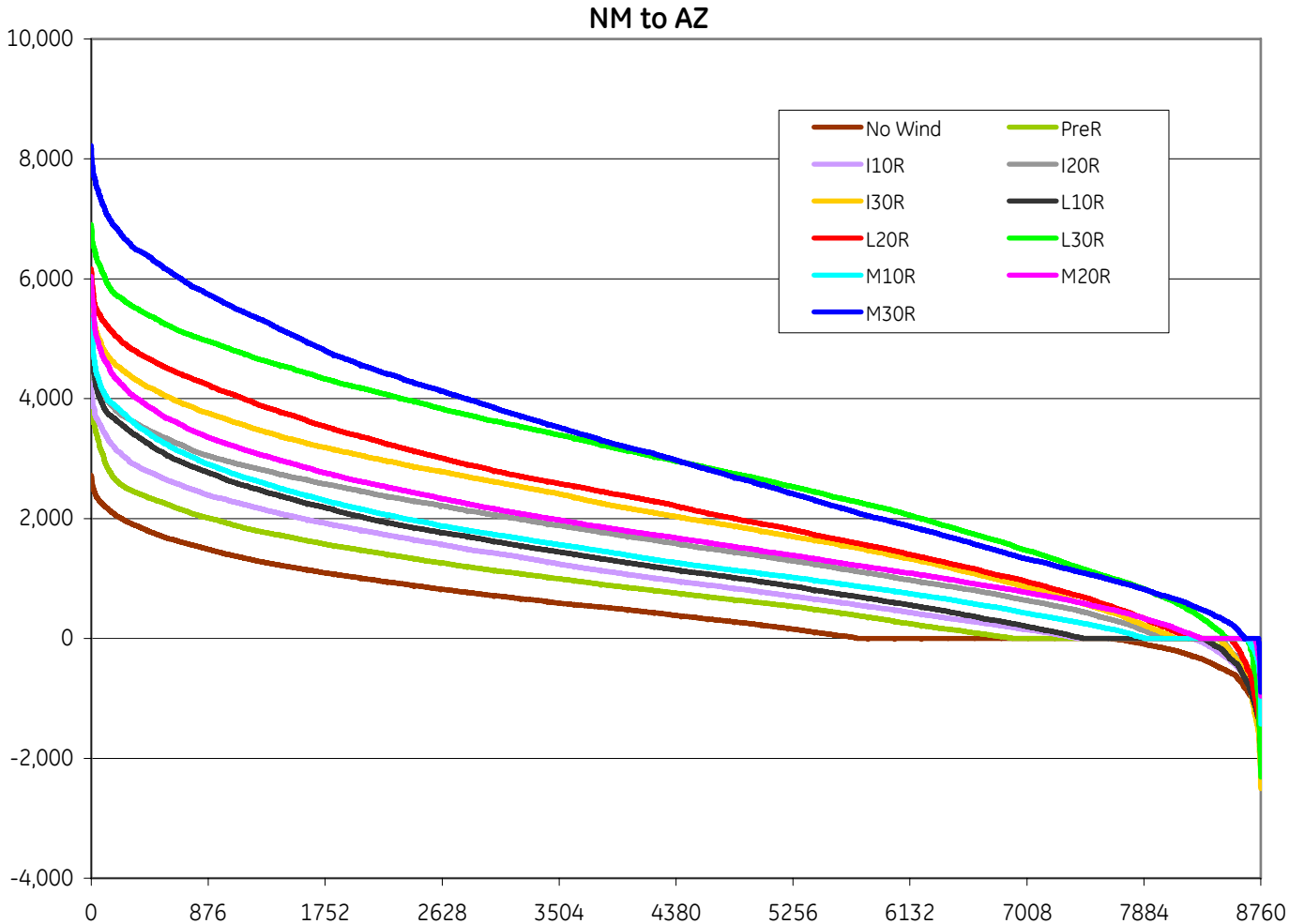
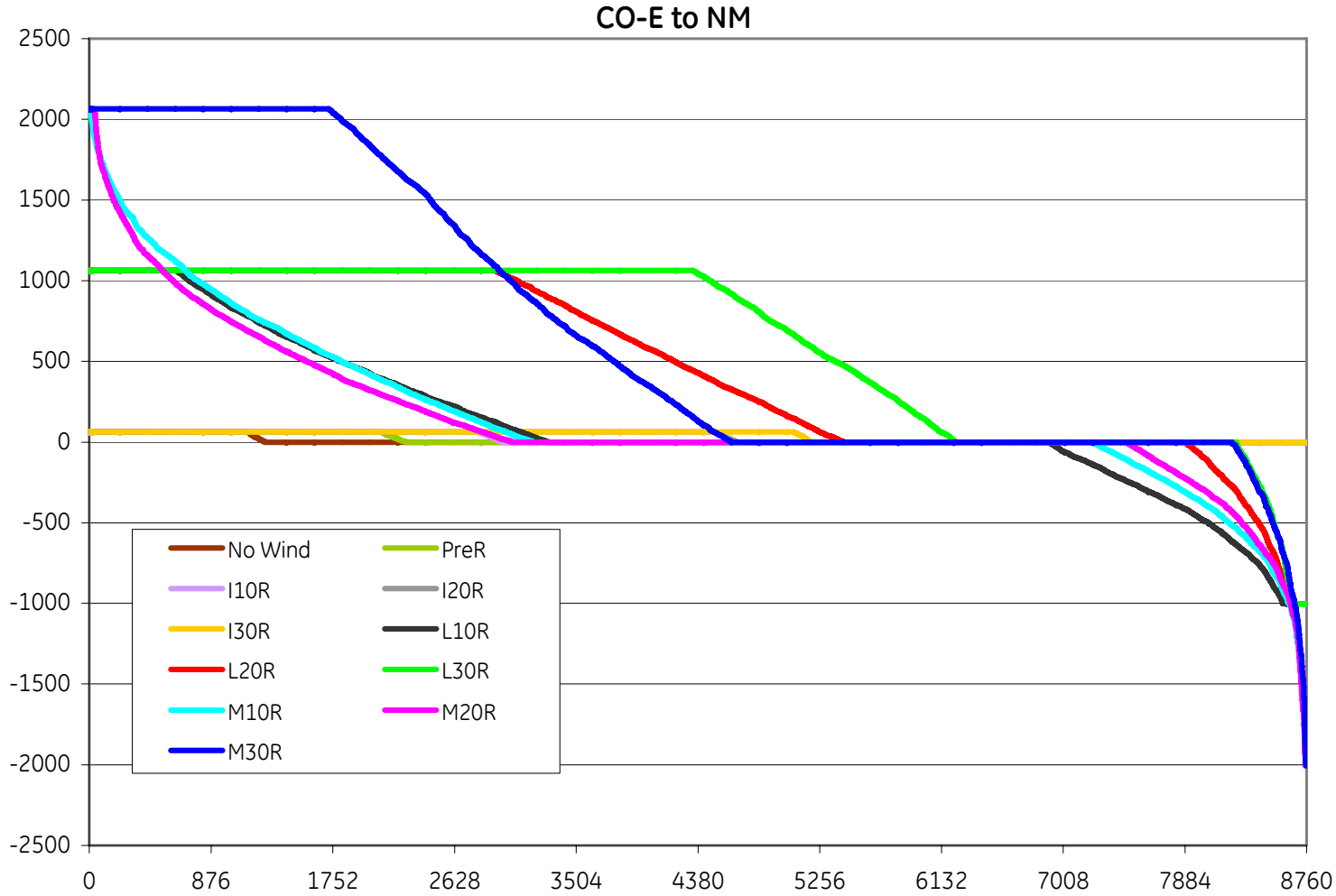


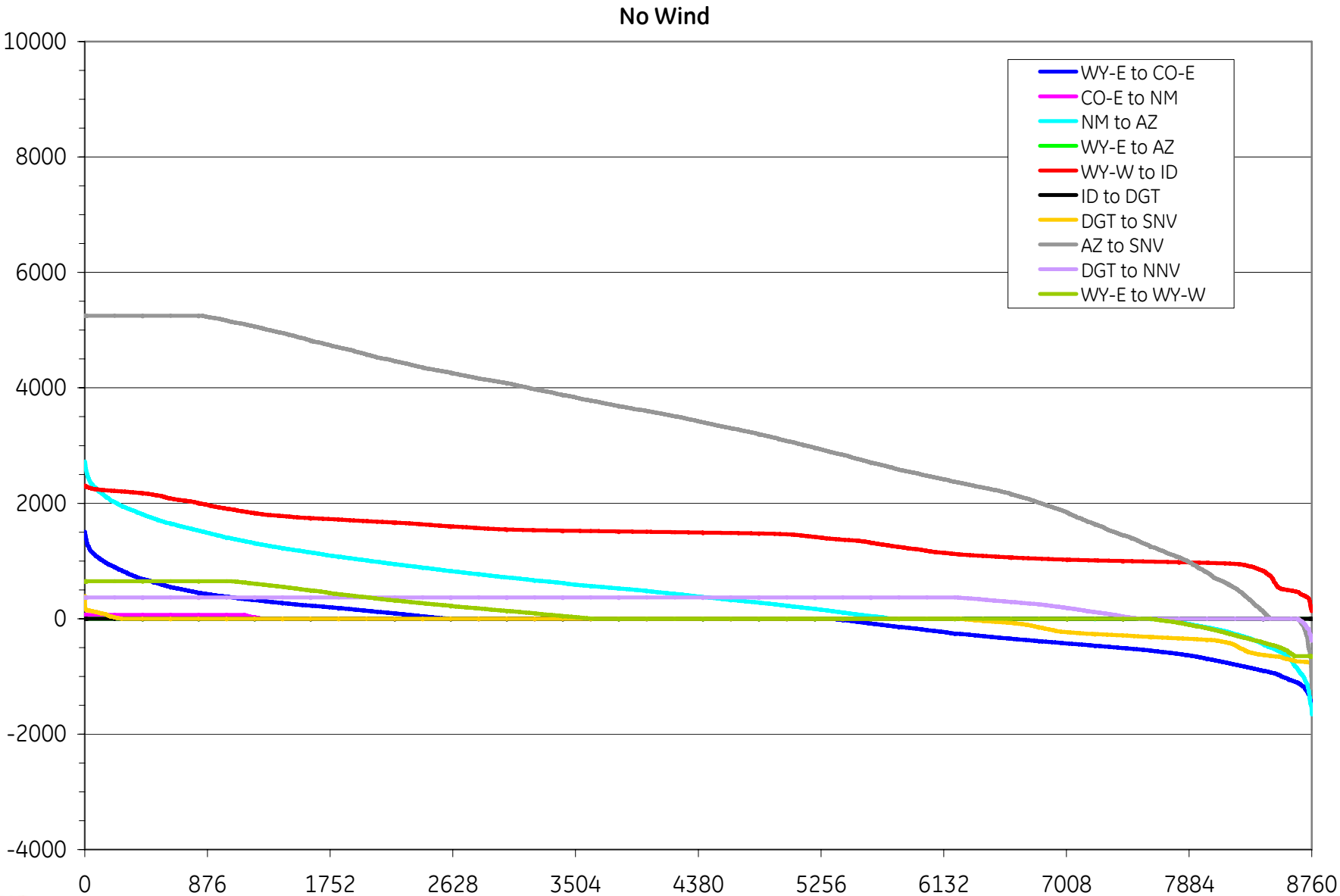
	No Wind	PreR	I10R	I20R	I30R	L10R	L20R	L30R	M10R	M20R	M30R
Max	6600	6600	6600	6600	6600	7600	7600	760	8600	8600	8600
# hrs at Max	0	0	0	0	0	0	0	0	0	0	0
# hrs Pos	5747	6912	7396	8047	8115	7433	8243	8510	7899	8315	8640
# hrs Neg	1122	464	509	316	319	421	227	103	104	43	17
CF Abs	9	14	17	25	32	17	30	386	16	21	36
CF	8	13	16	24	31	16	30	384	16	21	36
Avg	513	862	1074	1613	2038	1253	2244	2920	1413	1788	3116



	No Wind	PreR	I10R	I20R	I30R	L10R	L20R	L30R	M10R	M20R	M30R
Max	64	64	64	64	64	1064	1064	1064	2064	2064	2064
# hrs at Max	1137	2098	2801	4485	5068	626	2912	4339	10	35	1724
# hrs Pos	1268	2283	2981	4661	5189	3309	5431	6235	3197	3044	4623
# hrs Neg	3835	3191	2227	1379	1146	1861	863	506	1558	1310	539
CF Abs	14	25	33	52	59	30	52	63	16	14	37
CF	13	24	33	52	58	12	43	58	8	7	33
Avg	8	16	21	33	37	124	459	615	166	146	689

Bubble MAPS Transmission Path Flows

- by Path
- by Scenario



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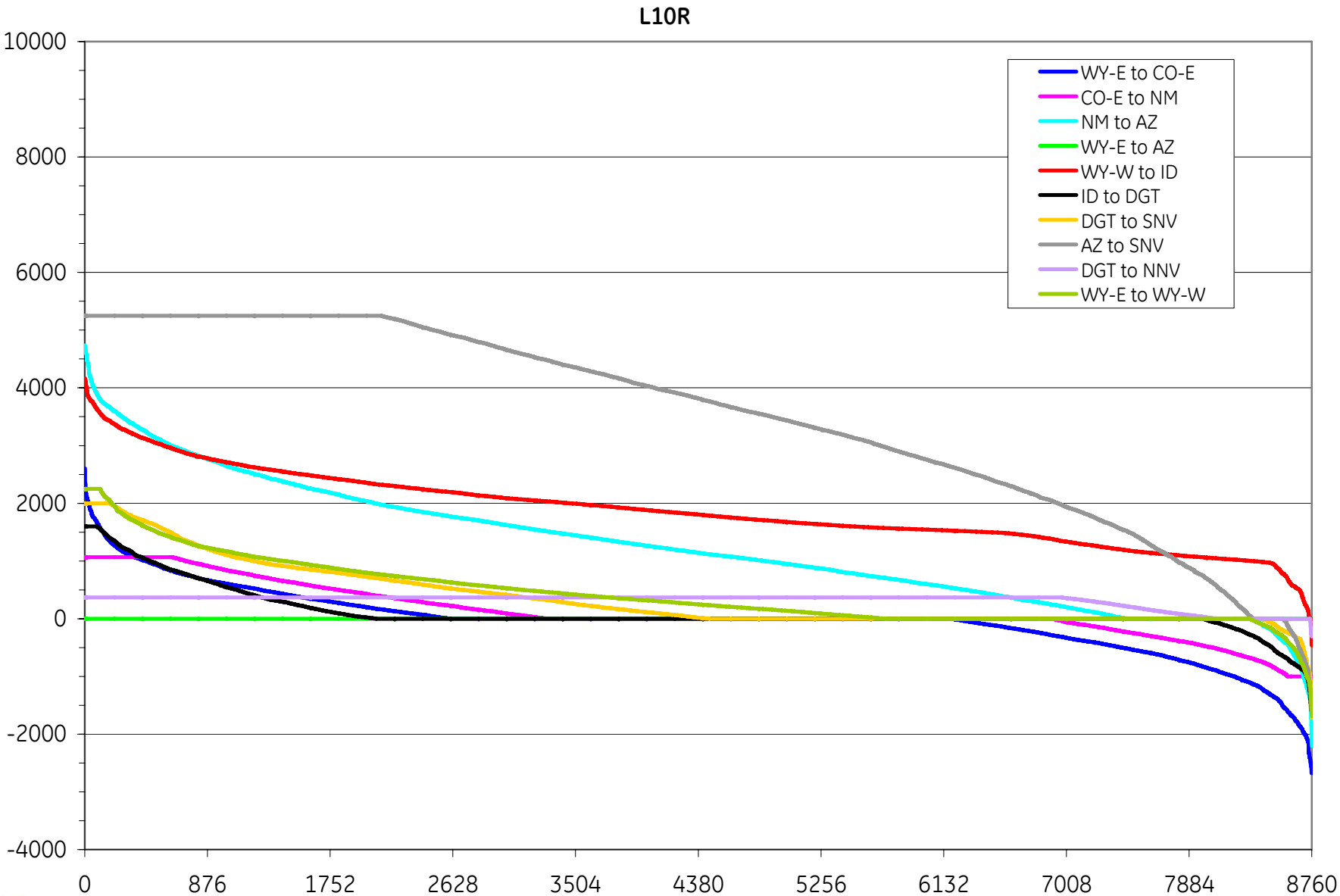

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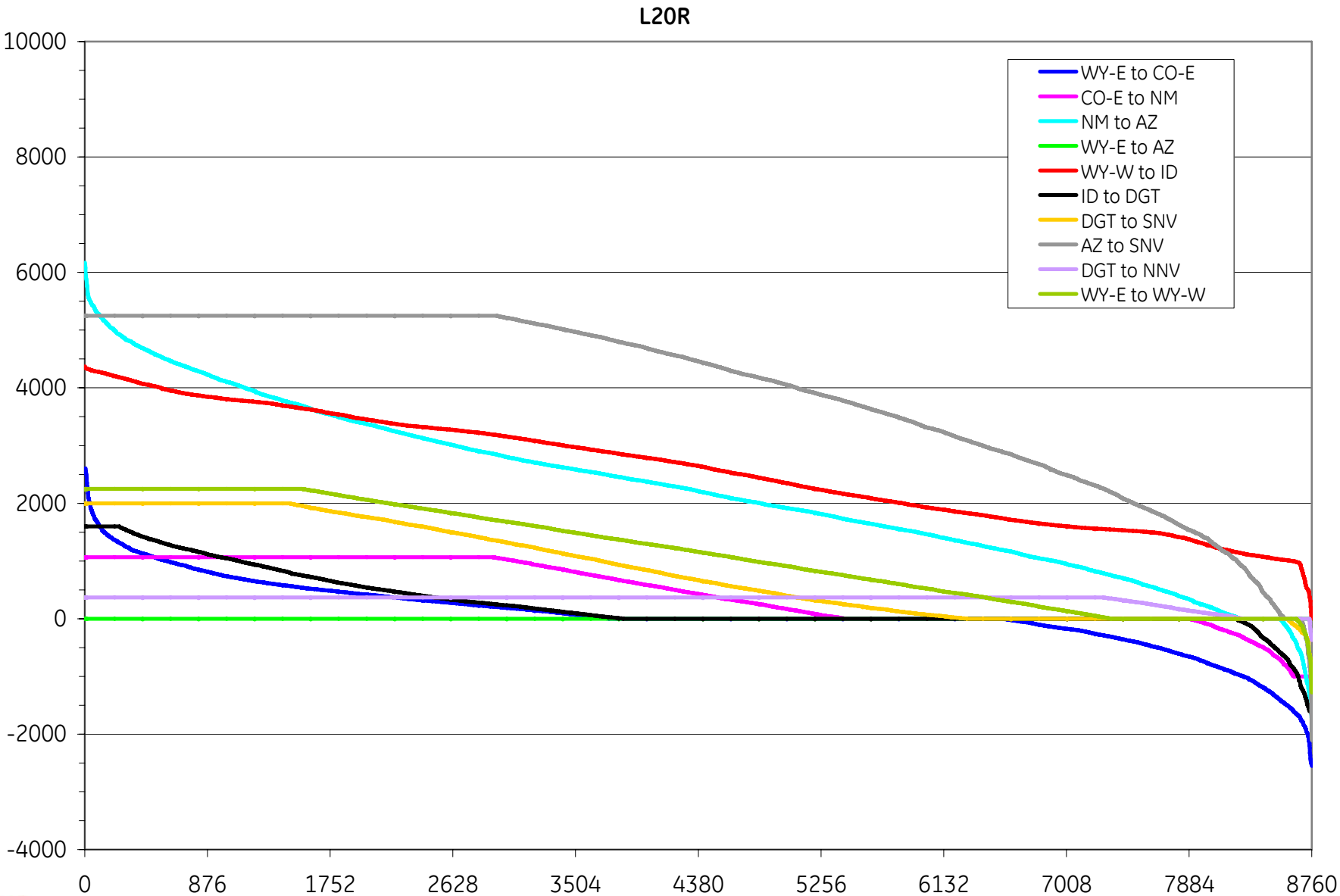

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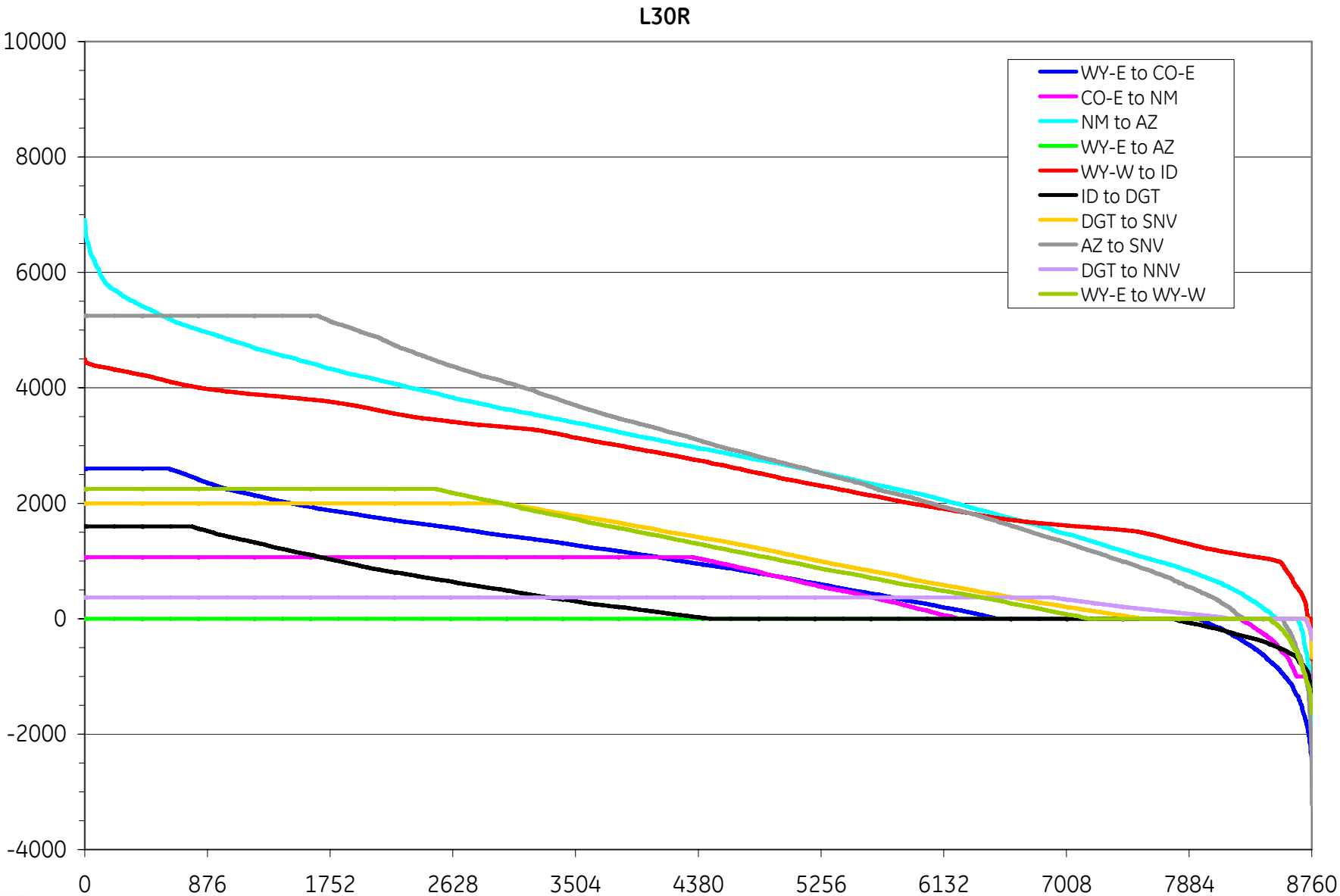

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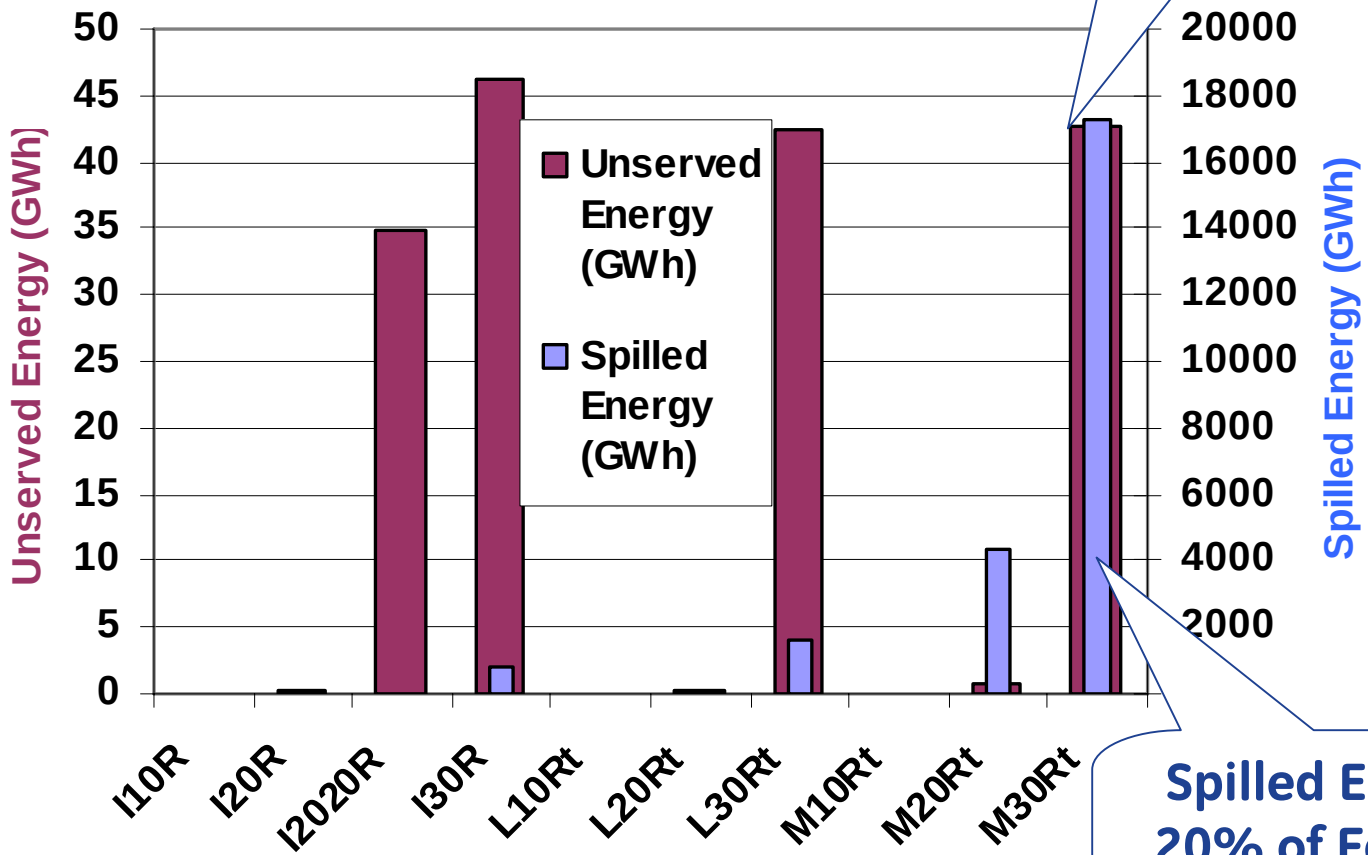
Transmission Sensitivity

- Examined the Local Priority and Mega Project scenarios without adding any new transmission.

Spilled and Unserved Energy w/o Transmission Expansion



Unserved Energy ~ 0.015% of Footprint Load.

Spilled Energy ~ 20% of Footprint wind generation.

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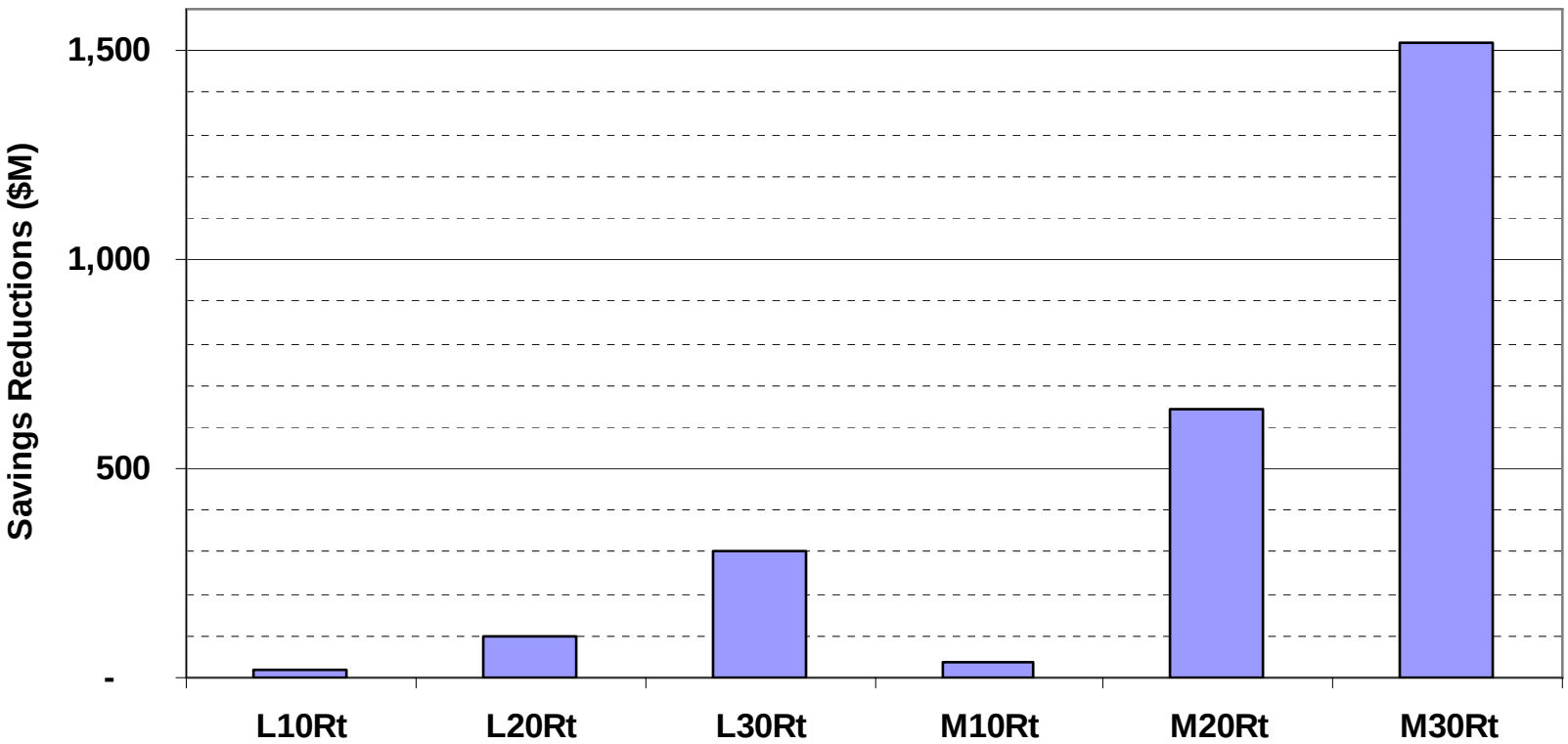
Savings Reductions due to No Transmission Expansion



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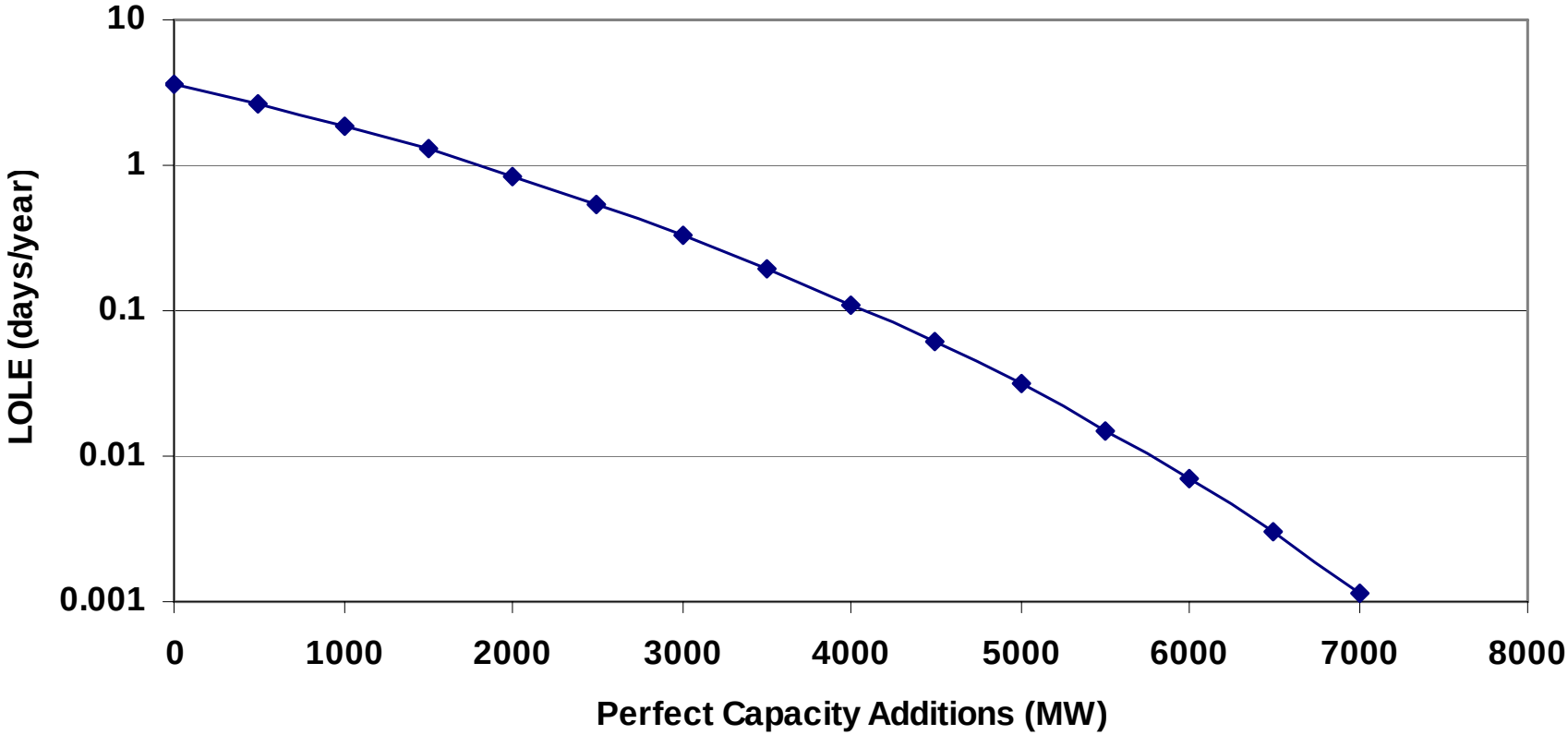
Reliability Analysis

- Examined In-Footprint region without transmission constraints to determine the capacity value of renewable resources compared to the generation resources and load profiles.
- Examined In-Area Scenario for 2006 load and renewable profiles.
- Considered LOLE in days/yr and hours/yr as well as Unserved Energy in MWh/yr.
- Examined Wind, CSP and PV independently and jointly for varying penetrations.

Risk vs Capacity Additions



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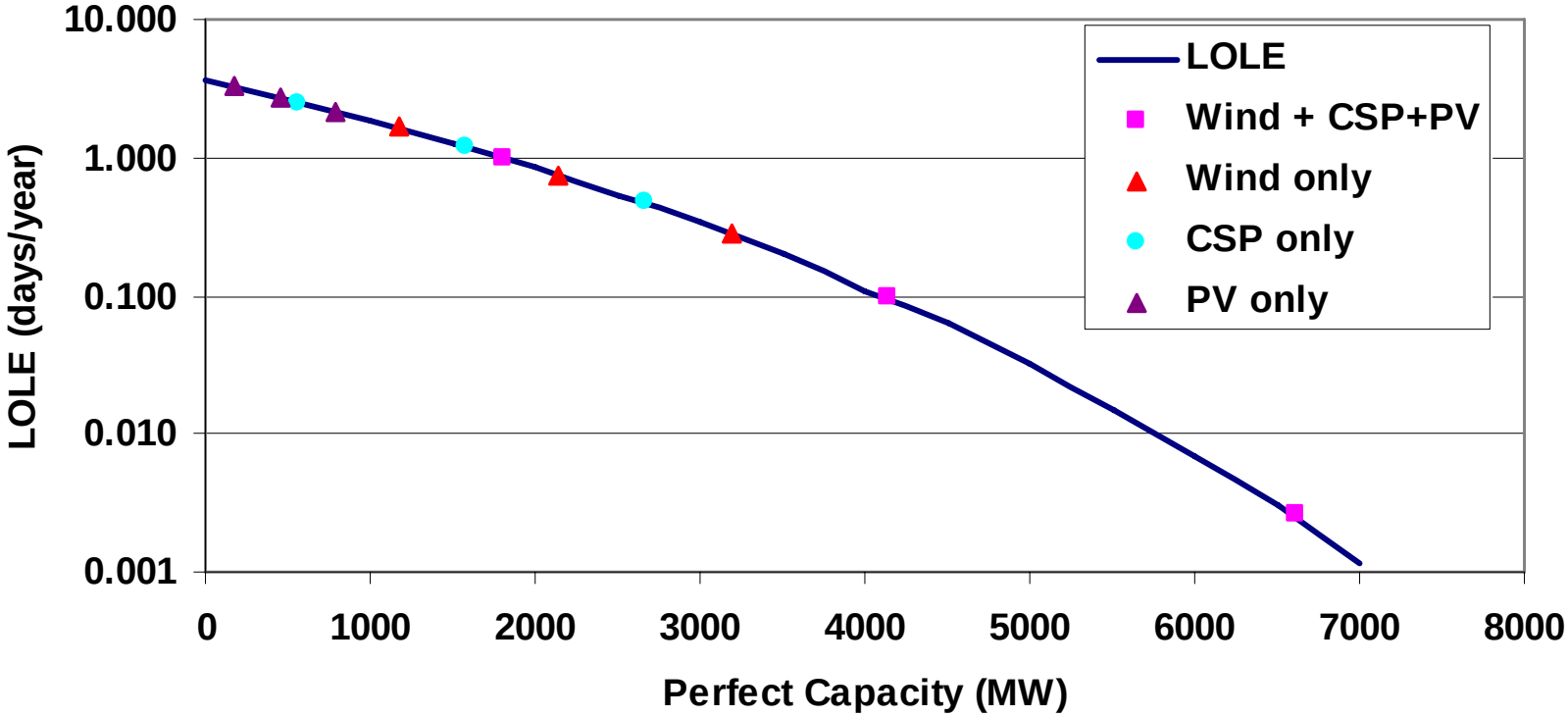
System Risk



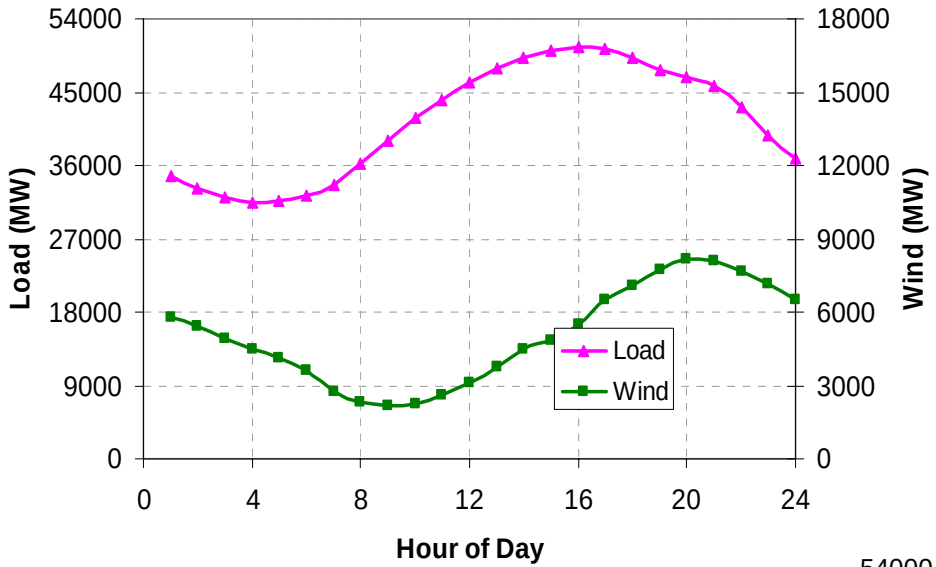
imagination at work

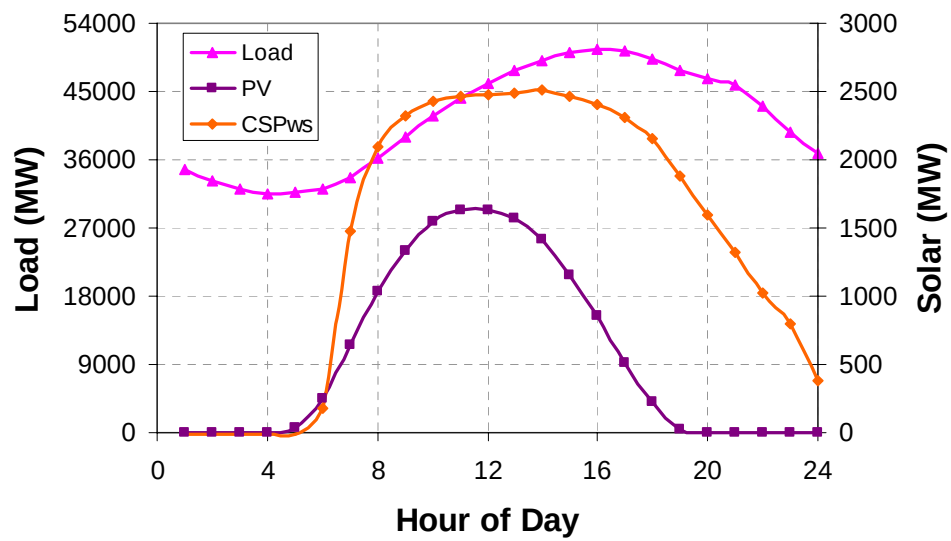
Capacity Values

Penetration	Total Renewables MW	Wind MW	CSP MW	PV MW
0%	0	0	0	0
10% Wind, 1% Solar	11,490	10,290	600	600
20% Wind, 3% Solar	23,350	19,950	1,700	1,700
30% Wind, 5% Solar	35,740	29,940	2,900	2,900

Wind + CSP+PV	Wind only	CSP only	PV only
0			
15.8%	11.4%	92.6%	28.6%
17.7%	10.8%	93.3%	26.9%
18.5%	10.7%	92.2%	26.9%

Study Area Load and Wind Average Daily Profiles for July 2006
(30% In Area Scenario)





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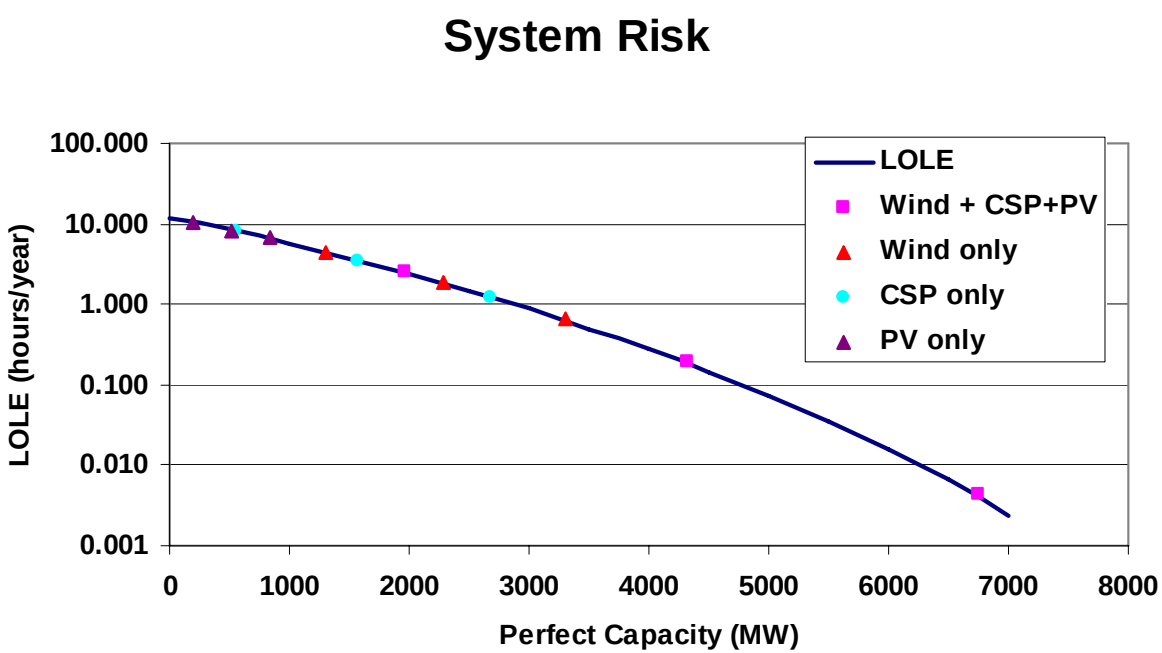
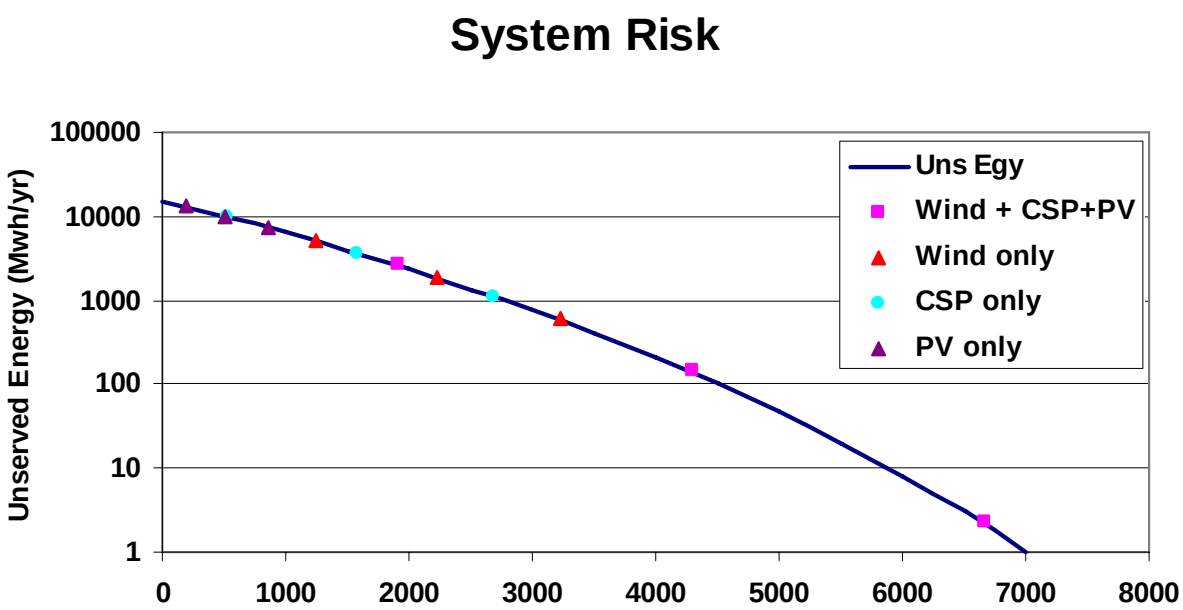
Hourly LOLE



Wind + CSP+PV	Wind only	CSP only	PV only
0			
17.1%	12.6%	90.8%	32.1%
18.5%	11.5%	92.7%	30.3%
18.9%	11.0%	92.6%	29.0%

imagination at work

Unserved Energy (MWh/yr)



Wind + CSP+PV	Wind only	CSP only	PV only
0			
16.6%	12.1%	88.5%	33.2%
18.4%	11.2%	92.6%	30.0%
18.6%	10.8%	92.6%	29.3%

imagination at work

Capacity Values vs Reliability Index

Penetration	Total MW	Wind MW	CSP MW	PV MW
0%	0	0	0	0
10% Wind, 1% Solar	11490	10,290	600	600
20% Wind, 3% Solar	23350	19,950	1,700	1,700
30% Wind, 5% Solar	35740	29,940	2,900	2,900

LOLE (days/yr)

Wind + CSP+PV	Wind only	CSP only	PV only
0			
1815	1175	555	172
4134	2147	1586	457
6610	3193	2673	781

Wind + CSP+PV	Wind only	CSP only	PV only
0%			
16%	11%	93%	29%
18%	11%	93%	27%
18%	11%	92%	27%

LOLE (hours/yr)

Wind + CSP+PV	Wind only	CSP only	PV only
0			
1962	1301	545	193
4323	2293	1575	516
6746	3304	2686	841

Wind + CSP+PV	Wind only	CSP only	PV only
0%			
17%	13%	91%	32%
19%	11%	93%	30%
19%	11%	93%	29%

Unserved Energy (MWh/yr)

Wind + CSP+PV	Wind only	CSP only	PV only
0			
1913	1243	531	199
4300	2228	1574	511
6665	3222	2685	851

Wind + CSP+PV	Wind only	CSP only	PV only
0%			
17%	12%	89%	33%
18%	11%	93%	30%
19%	11%	93%	29%

Average

Wind + CSP+PV	Wind only	CSP only	PV only
0			
1896	1240	544	188
4252	2223	1578	494
6674	3240	2682	824

Wind + CSP+PV	Wind only	CSP only	PV only
0%			
17%	12%	91%	31%
18%	11%	93%	29%
19%	11%	92%	28%

Capacity Values vs Scenario

In Area Scenario

Wind + CSP+PV	Wind only	CSP only	PV only
0.0%			
15.8%	11.4%	92.6%	28.6%
17.7%	10.8%	93.3%	26.9%
18.5%	10.7%	92.2%	26.9%

Local Priority Scenario

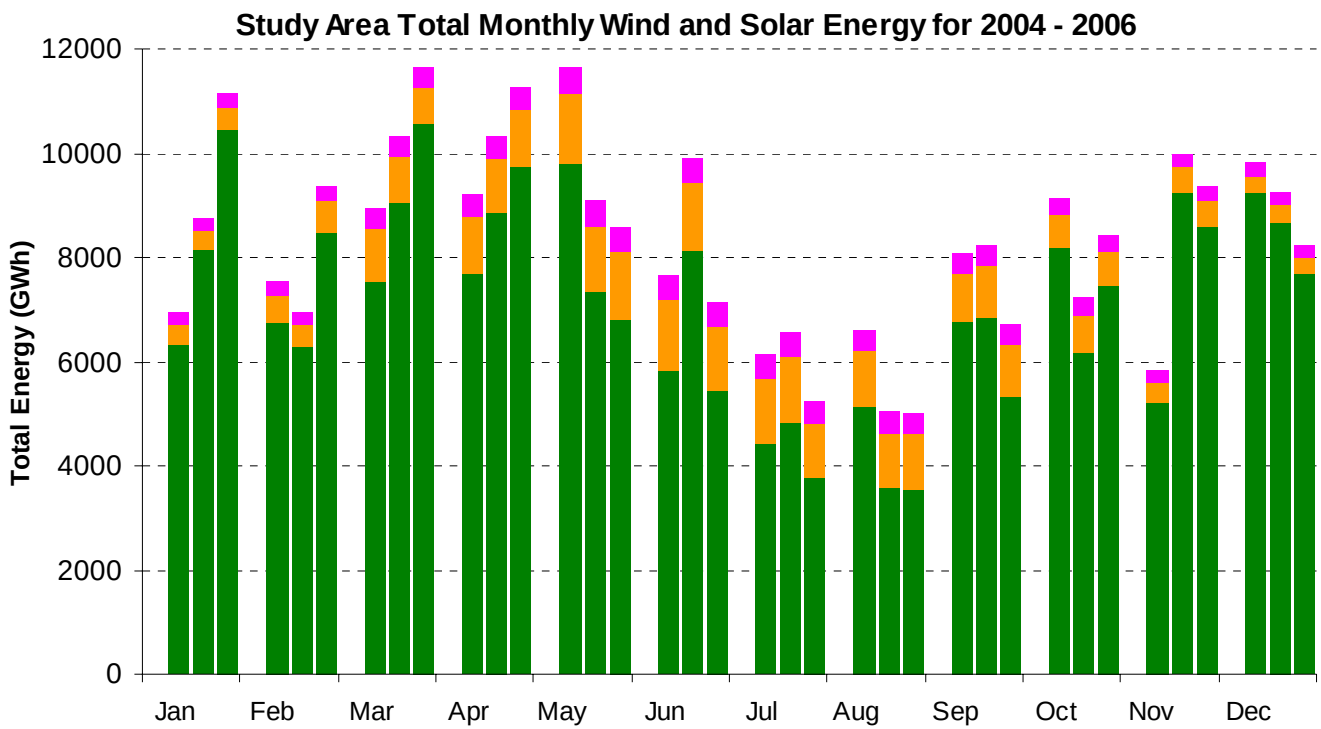
All Shapes	Wind only	CSP only	PV only
0			
16.5%	11.4%	92.6%	28.6%
18.7%	11.3%	93.3%	26.9%
18.8%	10.5%	92.2%	26.9%

Mega Project Scenario

All Shapes	Wind only	CSP only	PV only
0			
18.5%	13.0%	91.6%	25.8%
19.0%	11.9%	94.1%	24.7%
19.3%	10.0%	92.8%	24.8%

Reliability Analysis – next step

- Examine variability of results with 2004 and 2005 data.



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