Statistical Analysis

Part I – Seasonal Monthly, Daily trends

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Analysis Narrative

Significant monthly/seasonal variation of wind and solar energy within footprint and across areas

- Penetration and variation issues less severe over large areas
- 30% is not always 30%

Daily coincidence of wind and solar with load leads to periods with high ramping requirements

- Impacts on net load peaks and valleys, increase in ramp
- Ramping issues less severe over large areas

Hour-to-hour variability

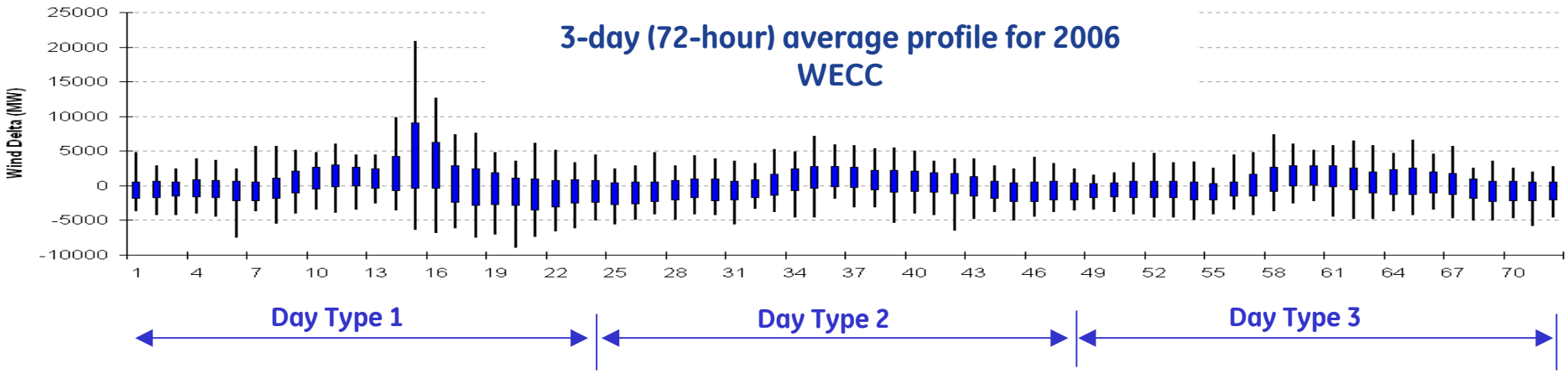
- Load is a significant contributor; wind and solar increase ramps at various times of day
- Mitigated over wide areas by spatial/temporal diversity

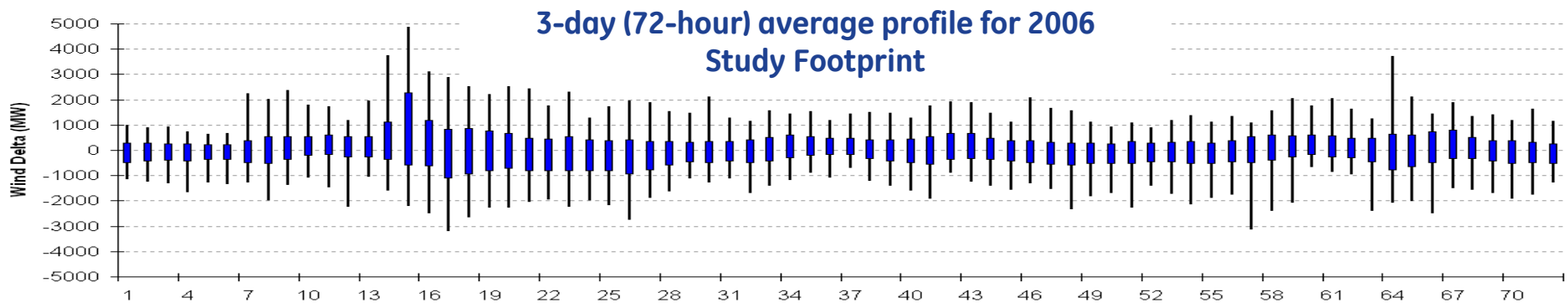
Predictability of wind (day-ahead forecast error)

- Forecast error is not a linear function of the wind forecast

Data Issues

3-Day Seam Data Issues





	Day 1 Sigma	Day 2 Sigma	Day 3 Sigma
WECC	2491	1675	1664
Footprint	1048	778	745

Significant statistical difference in variability between day type 1 and other day types

3-Day Seam Data Issues

All statistical analysis from this point forward will focus on 2/3 of the year*

- Day type 1 is removed for load, wind and solar
- Energy calculations are scaled up by 50%
- Data counts results are scaled up by 50%
- Average profiles and duration plots are relatively unaffected
- Percentage and per unit results unaffected

* Unless otherwise noted

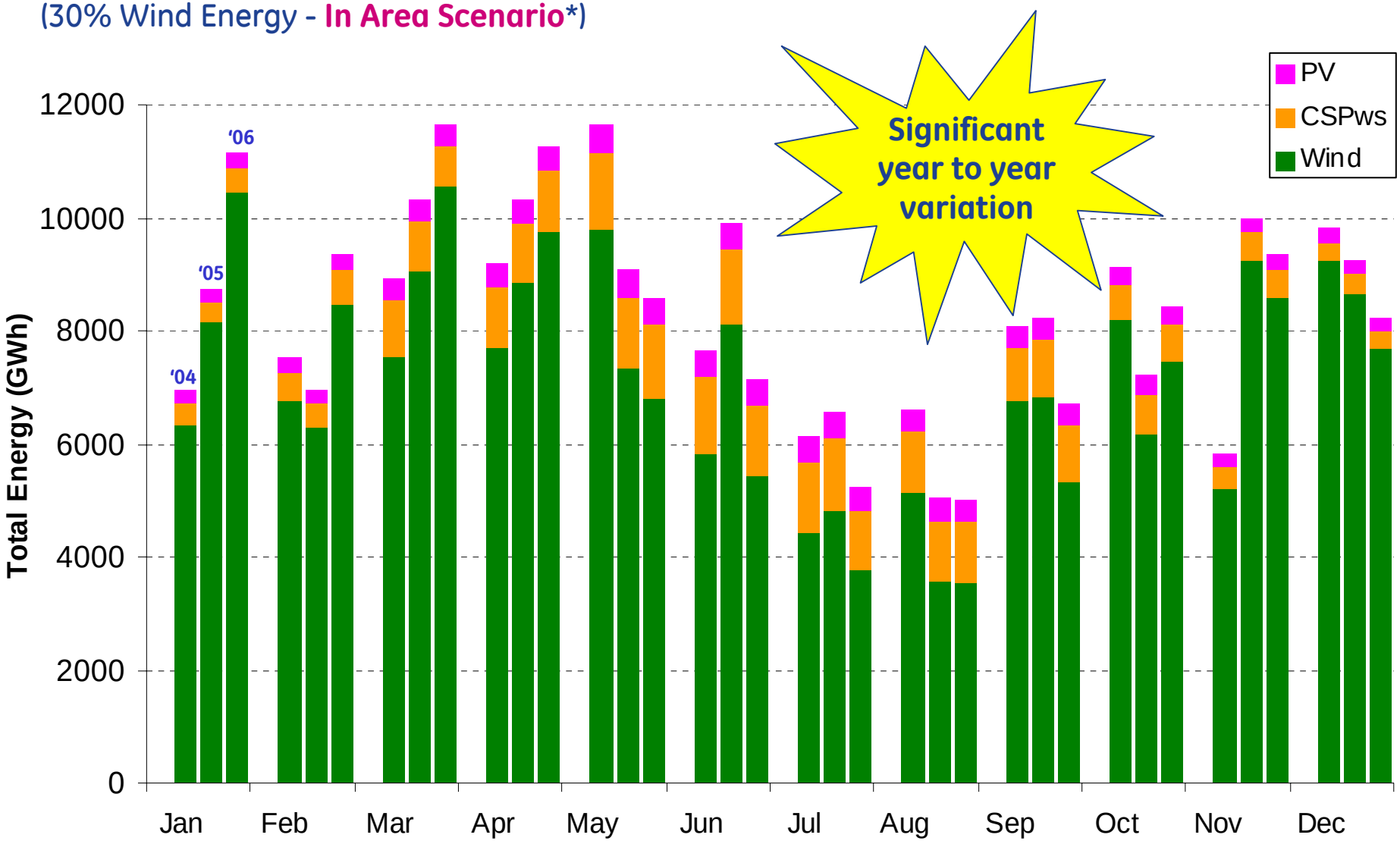
Part I

Yearly, Seasonal and Monthly Trends

Monthly Energy Comparison

Footprint Monthly Energy from Wind and Solar for 2004 – 2006

(30% Wind Energy - **In Area Scenario***)



Notable difference in W + S energy across the months and over the years

* Based on original data - all days in year

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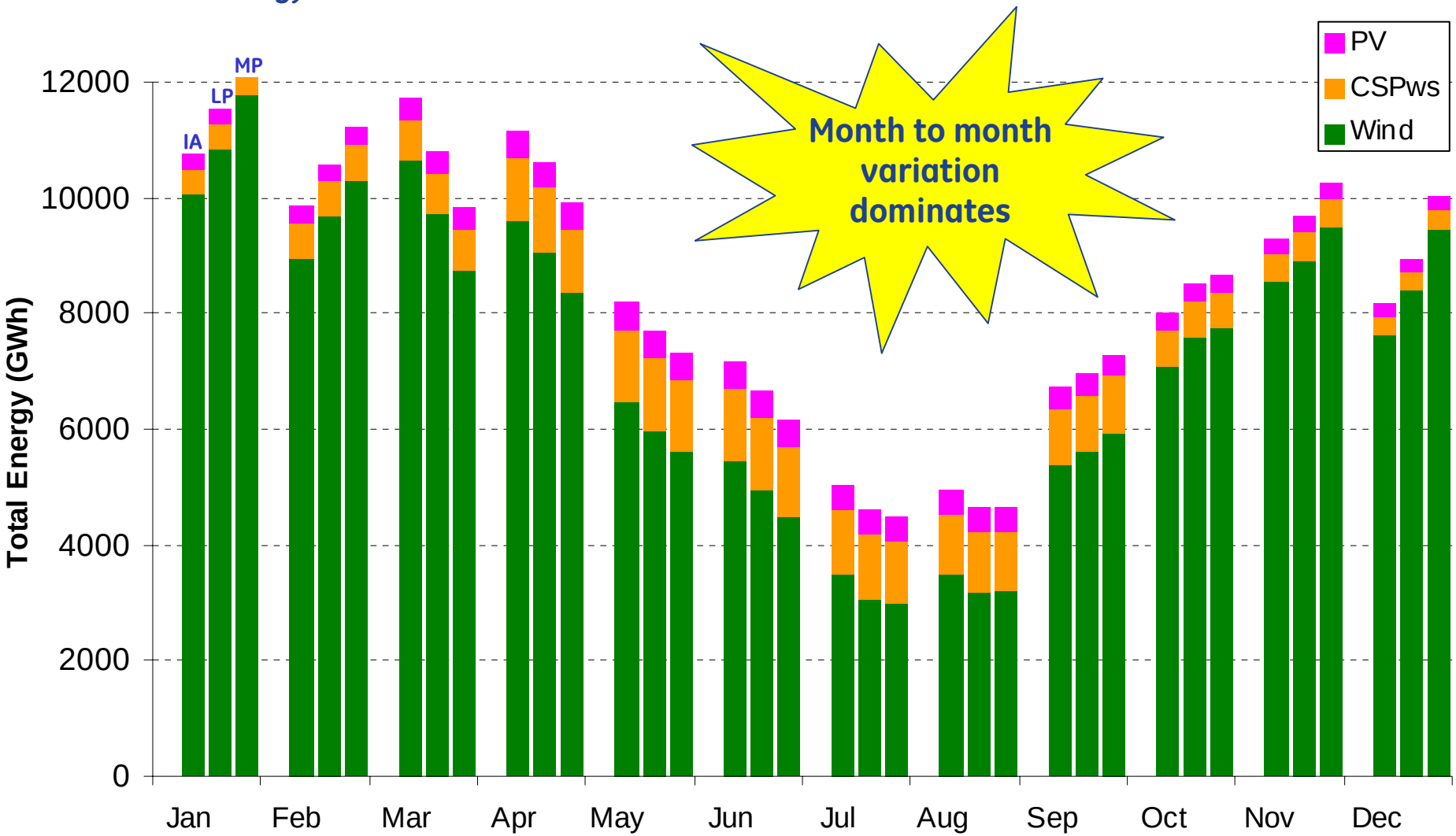
Footprint Monthly Energy from Wind and Solar for 3 Scenarios

(30% Wind Energy – **Year 2006***)



Much less difference in W + S energy between the scenarios than across months

* Based on 2/3 of data – day type 1 deleted

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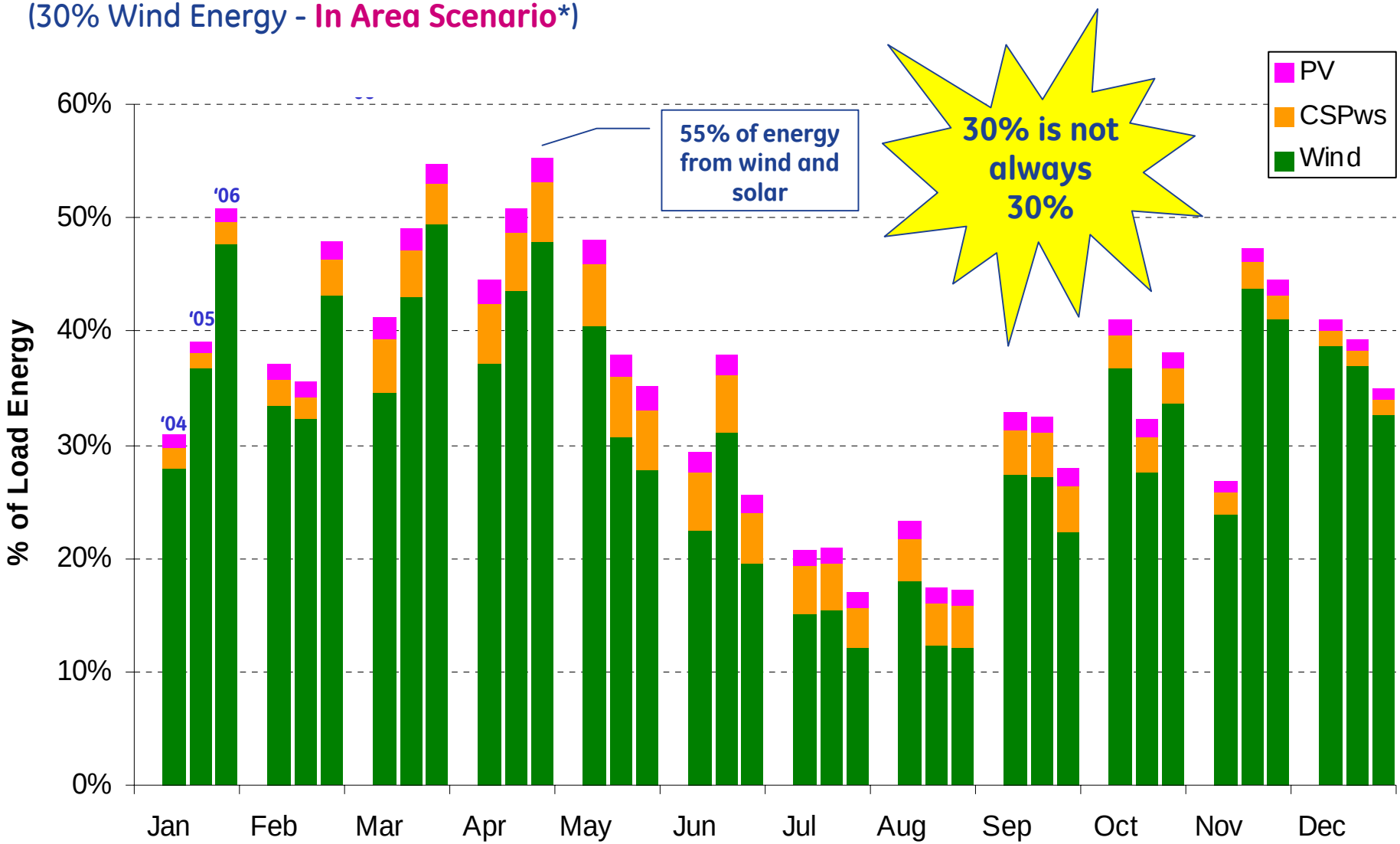
Footprint % Monthly Energy from Wind and Solar for 2004 – 2006

(30% Wind Energy - **In Area Scenario***)



2006 percent monthly energy ranges from 18% (Jul) to 55% (Apr) in study footprint

* Based on original data - all days in year

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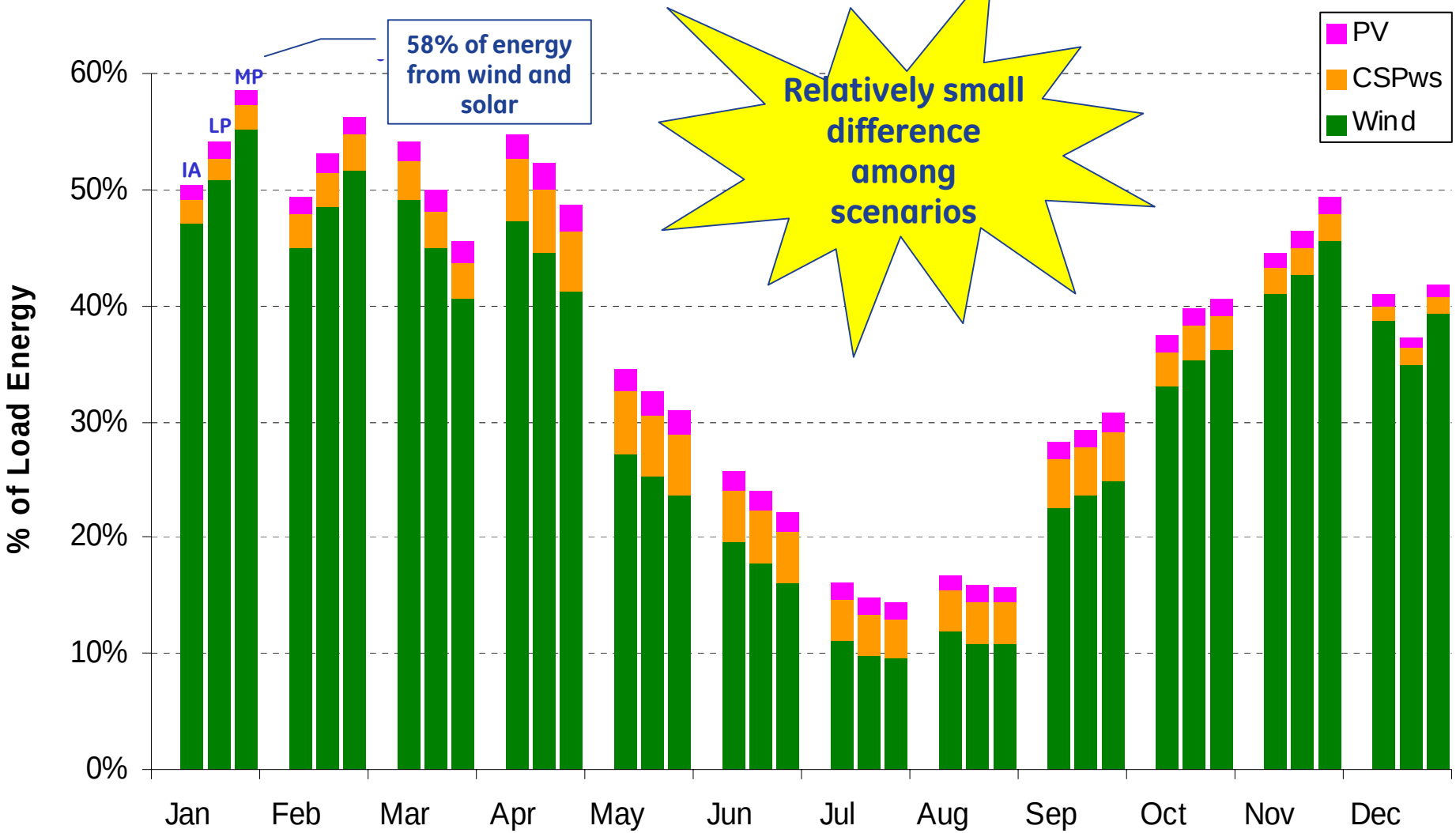
Footprint % Monthly Energy from Wind and Solar for 3 Scenarios

(30% Wind Energy – **Year 2006***)



Mega project percent monthly energy ranges from 14% (Jul) to 58% (Jan) in study footprint

* Based on 2/3 of data – day type 1 deleted

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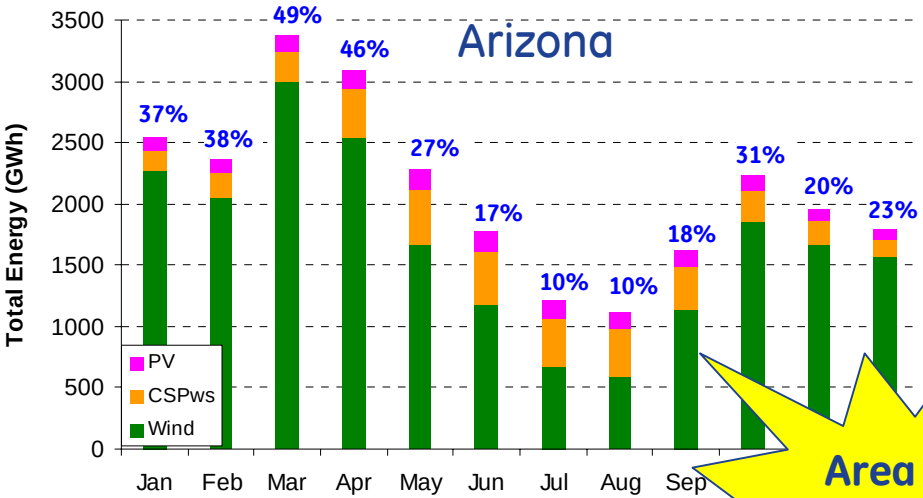
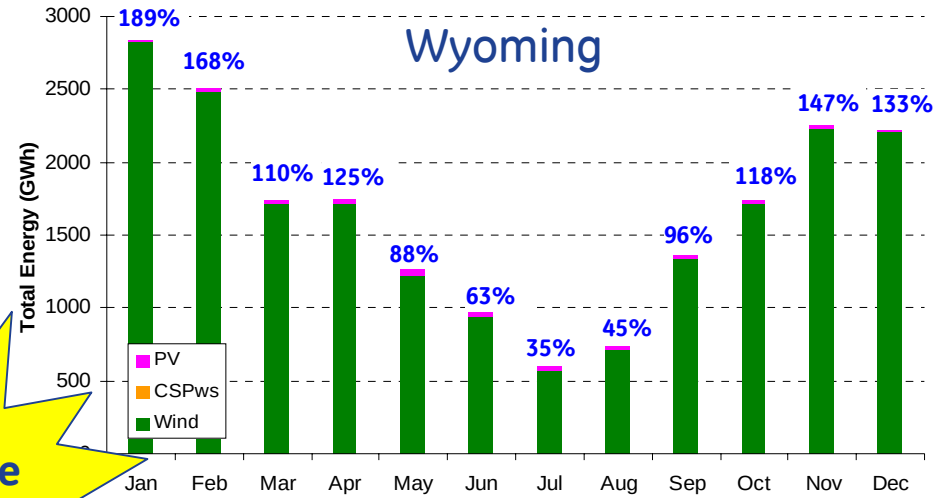
Total and Percent Monthly Energy from Wind and Solar for Areas

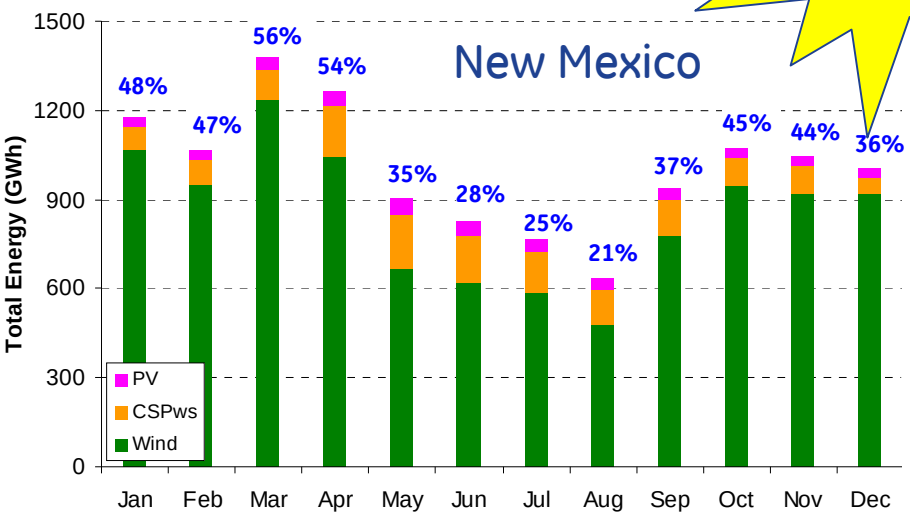
(30% Wind Energy - **LP Scenario**)

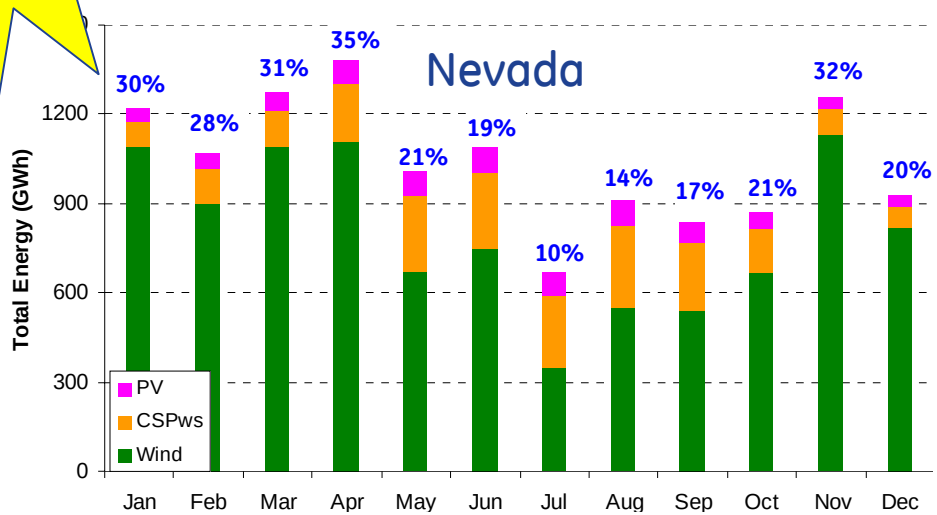
% of monthly load energy





Area size matters!





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Large amount of wind in small areas → balancing issues

Summary of Percent Monthly Energy from Wind and Solar
(30% Wind Energy in Footprint)

IA Scenario

	CO-W	WY	NM	CO-E	NV	Ariz	FP	WECC
Jan	47%	52%	45%	50%	54%	50%	50%	37%
Feb	53%	50%	44%	51%	48%	50%	49%	34%
Mar	47%	33%	53%	45%	60%	66%	54%	37%
Apr	62%	37%	51%	51%	60%	61%	55%	37%
May	40%	31%	33%	35%	34%	36%	35%	29%
Jun	36%	24%	27%	27%	30%	22%	26%	22%
Jul	18%	14%	24%	17%	17%	13%	16%	16%
Aug	20%	16%	20%	14%	24%	13%	17%	17%
Sep	35%	30%	35%	34%	27%	23%	28%	22%
Oct	40%	34%	42%	38%	31%	40%	37%	27%
Nov	47%	43%	41%	43%	57%	40%	45%	32%
Dec	33%	36%	34%	36%	35%	31%	34%	25%

LP Scenario

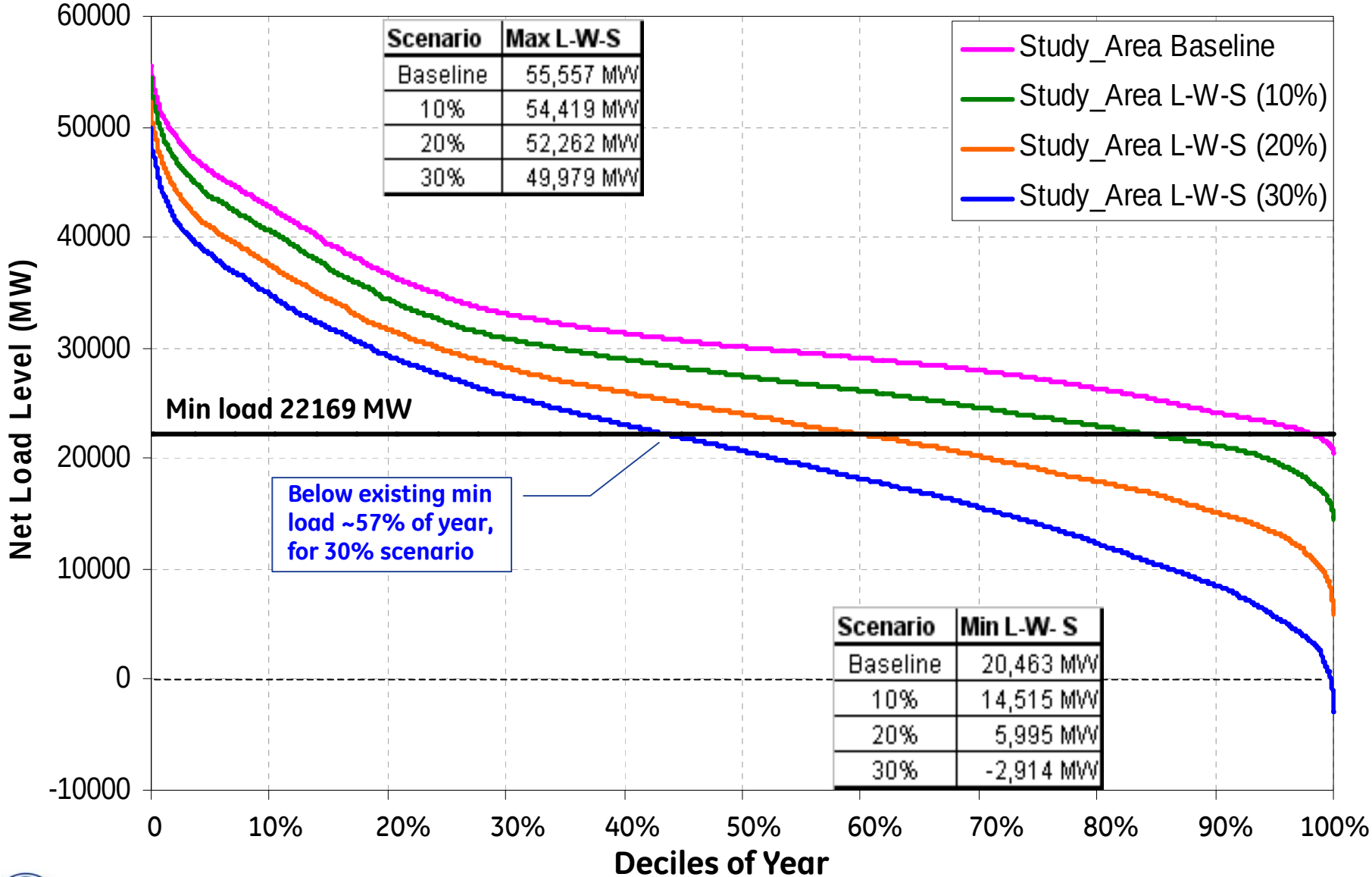
	CO-W	WY	NM	CO-E	NV	Ariz	FP	WECC
Jan	34%	189%	48%	42%	30%	37%	54%	38%
Feb	38%	168%	47%	44%	28%	38%	53%	35%
Mar	33%	110%	56%	38%	31%	49%	50%	35%
Apr	45%	125%	54%	43%	35%	46%	52%	36%
May	30%	88%	35%	30%	21%	27%	33%	28%
Jun	28%	63%	28%	24%	19%	17%	24%	22%
Jul	14%	35%	25%	15%	10%	10%	15%	15%
Aug	16%	45%	21%	13%	14%	10%	16%	16%
Sep	27%	96%	37%	29%	17%	18%	29%	22%
Oct	29%	118%	45%	33%	21%	31%	40%	27%
Nov	35%	147%	44%	37%	32%	30%	46%	33%
Dec	23%	133%	36%	30%	20%	23%	37%	26%

MP Scenario

	CO-W	WY	NM	CO-E	NV	Ariz	FP	WECC
Jan	8%	481%	73%	23%	12%	14%	59%	39%
Feb	9%	433%	71%	24%	13%	16%	56%	36%
Mar	8%	410%	82%	21%	13%	19%	46%	34%
Apr	11%	433%	78%	24%	16%	21%	49%	35%
May	8%	280%	49%	17%	10%	15%	31%	28%
Jun	7%	216%	39%	14%	9%	11%	22%	21%
Jul	4%	121%	33%	10%	5%	8%	14%	15%
Aug	4%	131%	29%	9%	7%	8%	16%	16%
Sep	7%	265%	53%	18%	8%	11%	31%	23%
Oct	7%	345%	64%	19%	10%	13%	41%	27%
Nov	8%	388%	67%	19%	13%	13%	49%	34%
Dec	6%	334%	60%	17%	8%	9%	42%	28%

Yearly Duration Plots

Study Footprint 2006 Net Load Duration – In Area Scenario



Scenario	Max L-W-S
Baseline	55,557 MW
10%	54,419 MW
20%	52,262 MW
30%	49,979 MW

Scenario	Min L-W- S
Baseline	20,463 MW
10%	14,515 MW
20%	5,995 MW
30%	-2,914 MW

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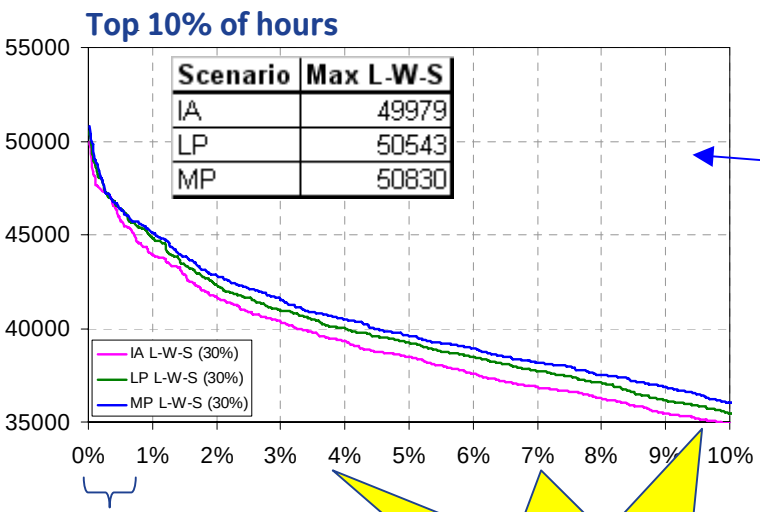
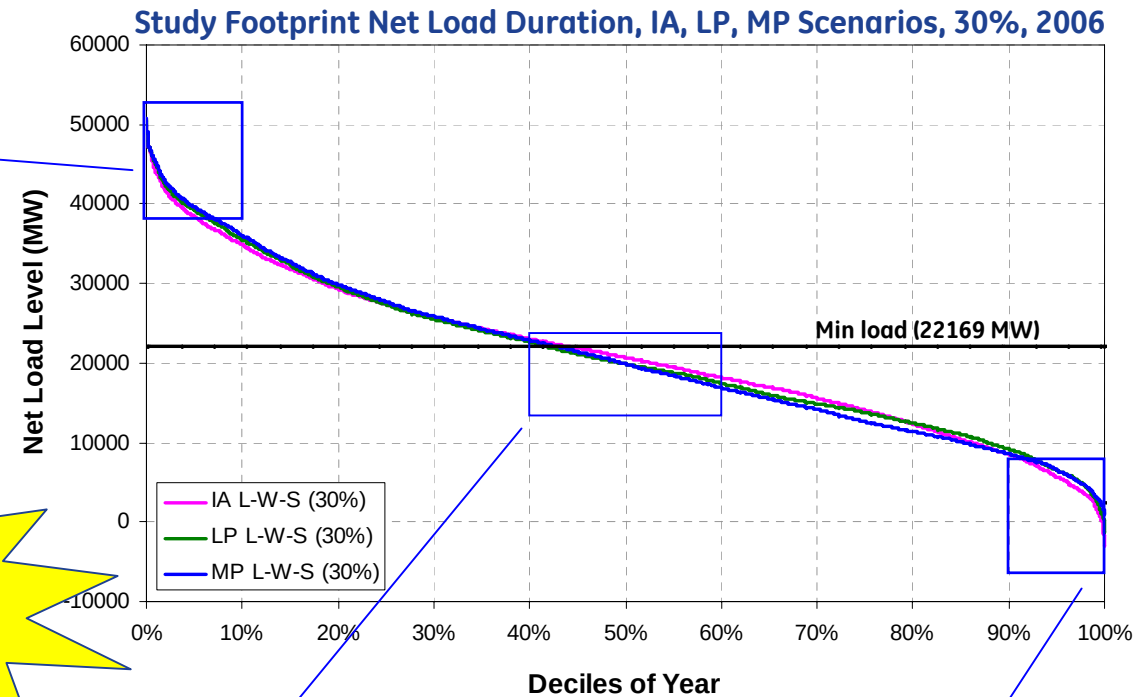
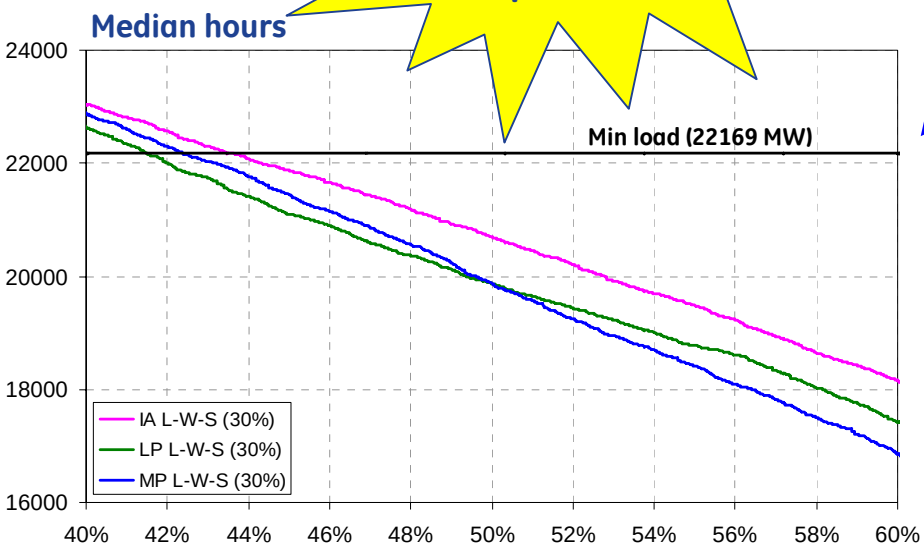
Study Footprint 2006 Net Load Duration Plots - IA, LP, MP

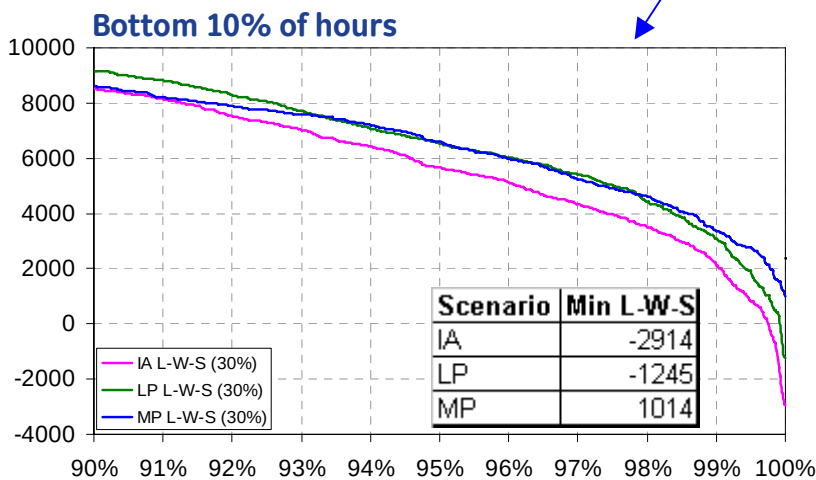
(30% Wind Energy in Footprint)



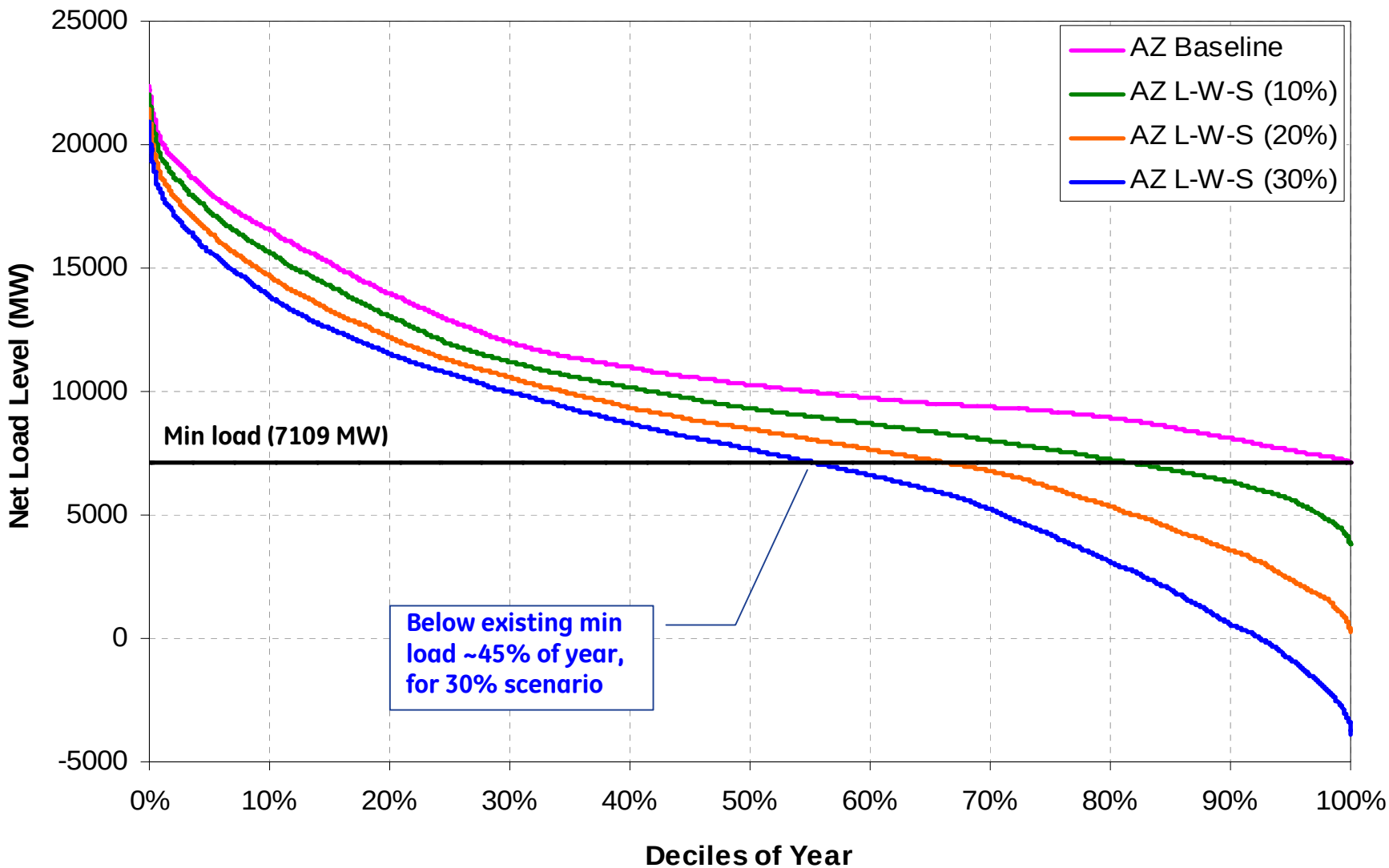


No significant differentiation at footprint level





Arizona 2006 Net Load Duration – In Area Scenario



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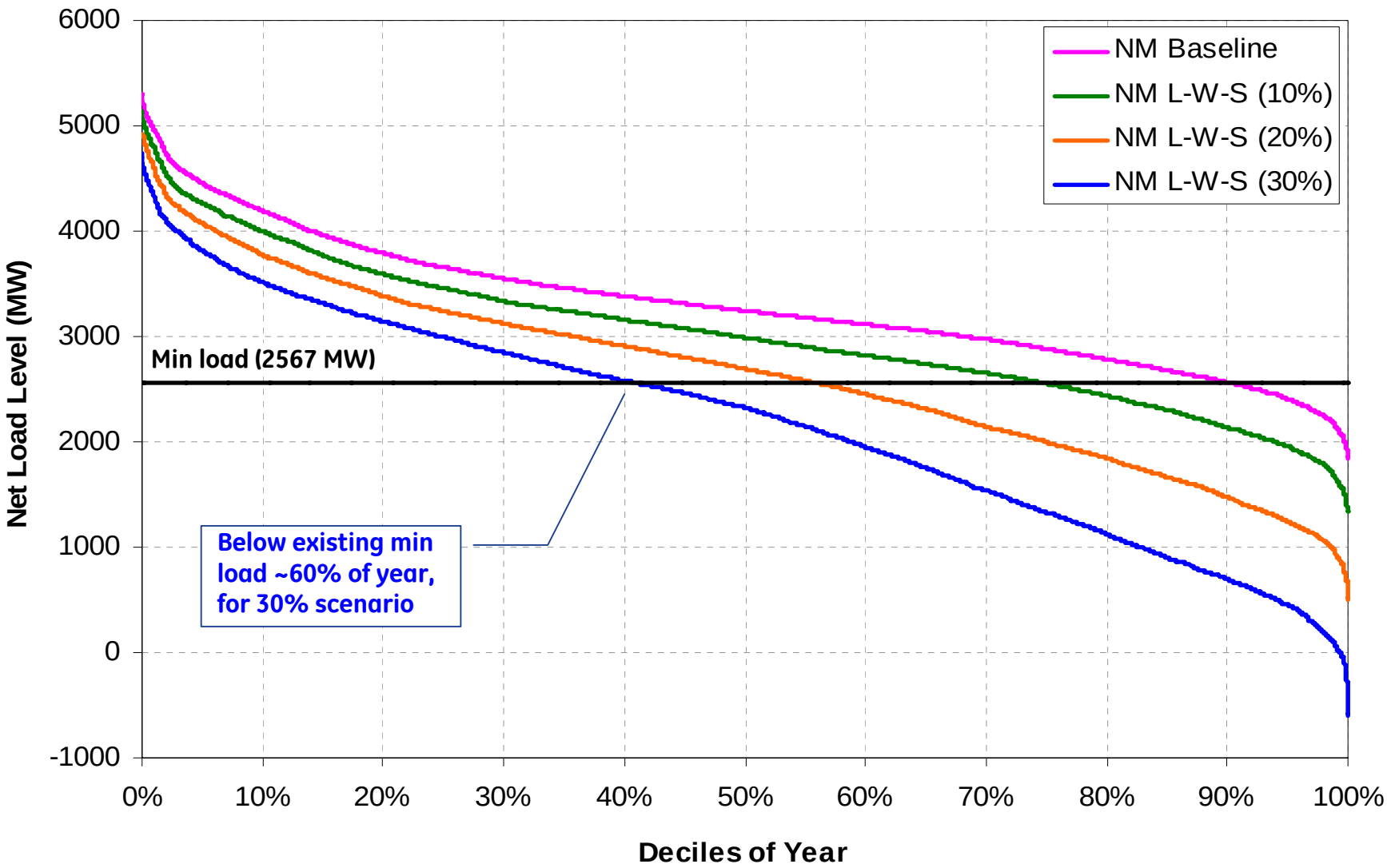
New Mexico 2006 Net Load Duration – Local Priority Scenario



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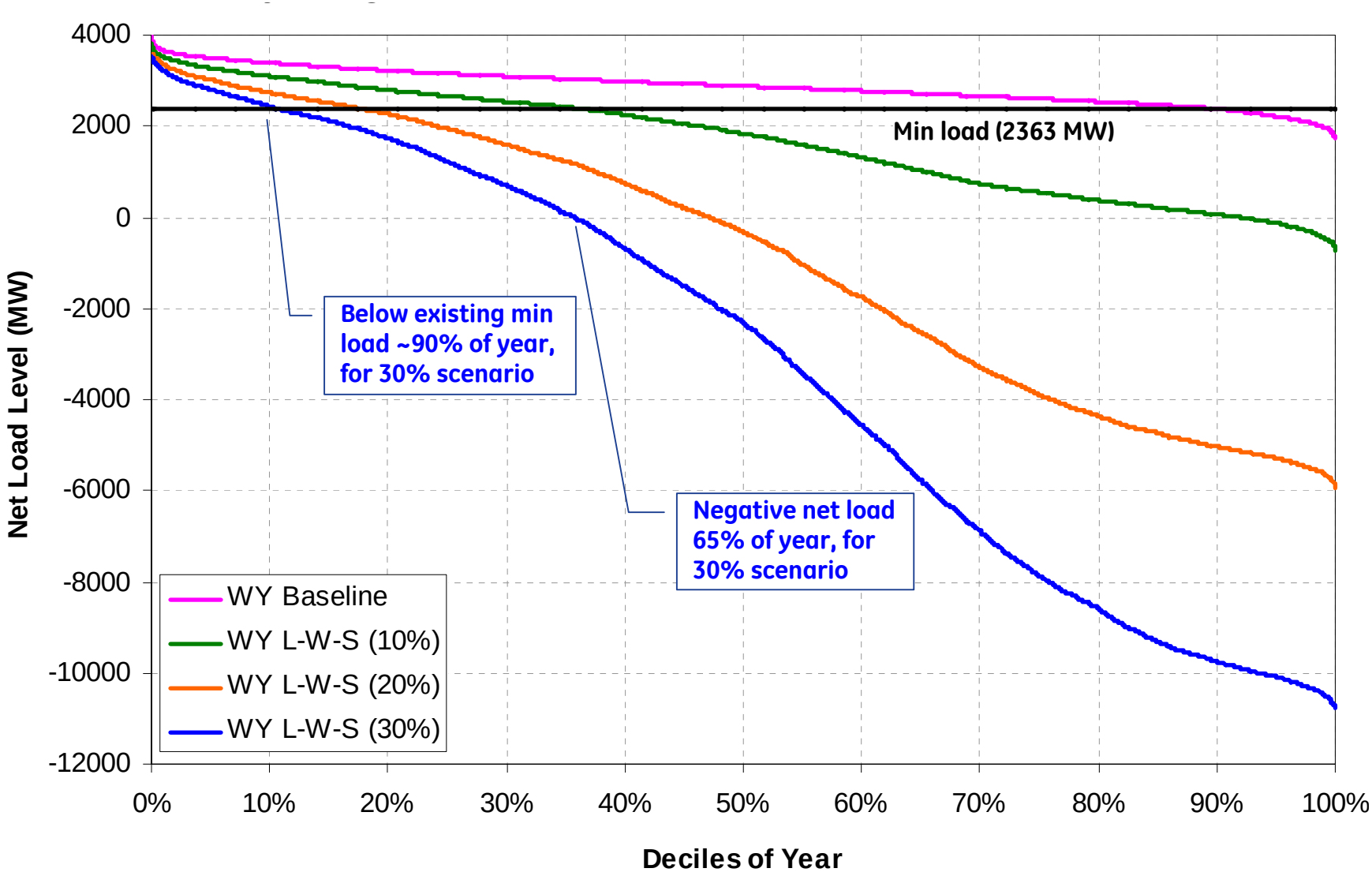
Wyoming 2006 Net Load Duration – Mega Project Scenario



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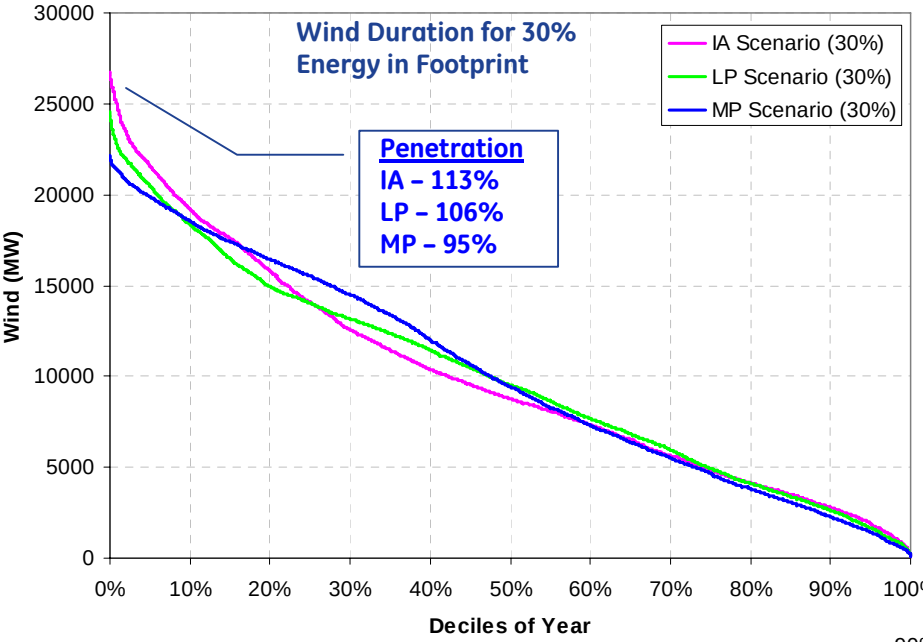
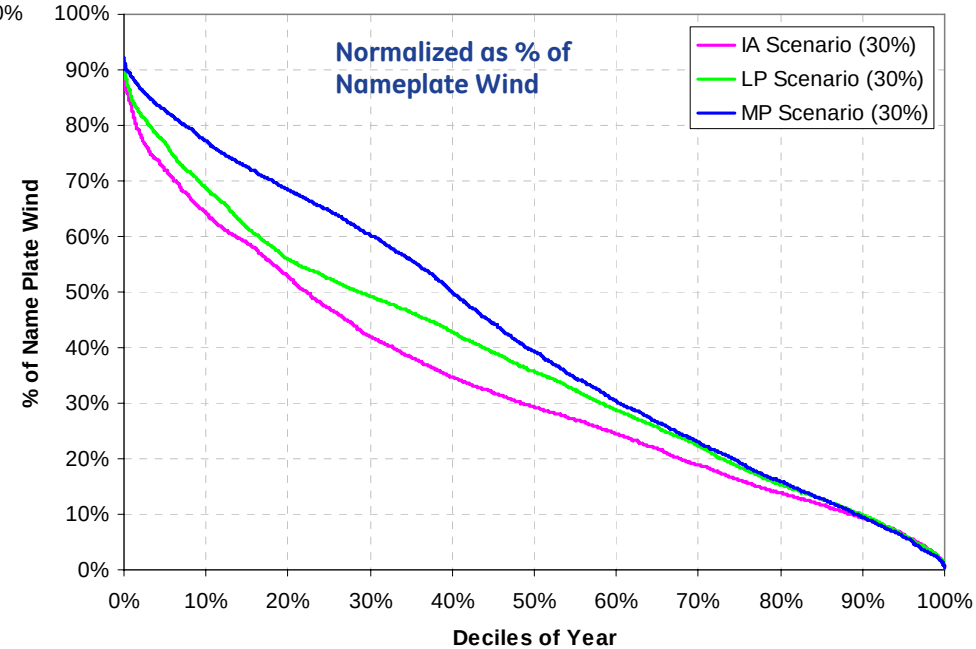
Study Footprint 2006 Wind Duration Plots - IA, LP, MP

(30% Wind Energy in Footprint)



Separation of traces due to difference in quality of wind resources



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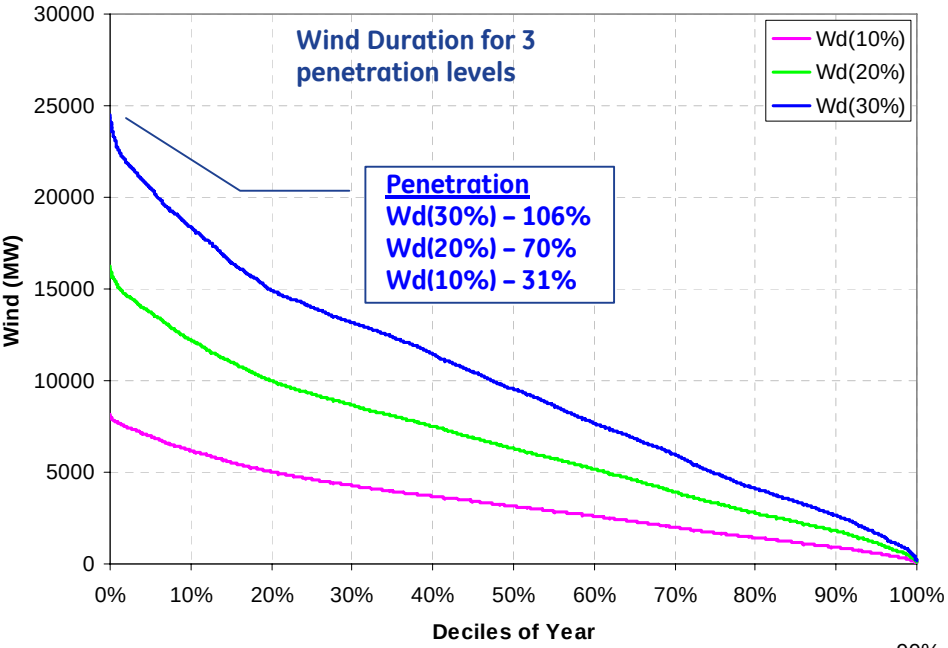
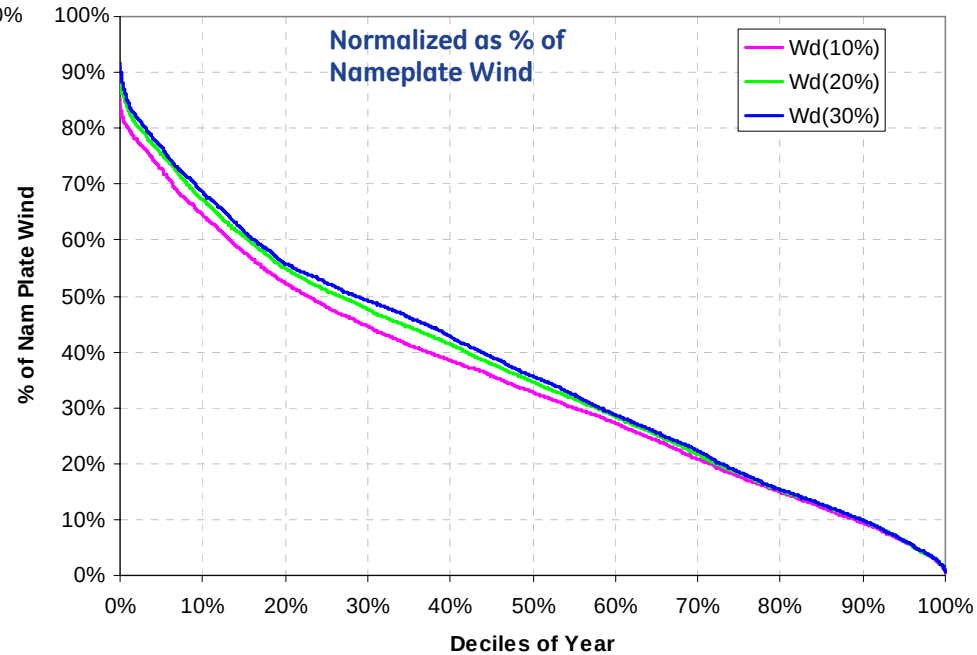
Study Footprint 2006 Wind Duration Plots - **LP Scenario**

(All penetration levels)



Small observable difference in normalized traces



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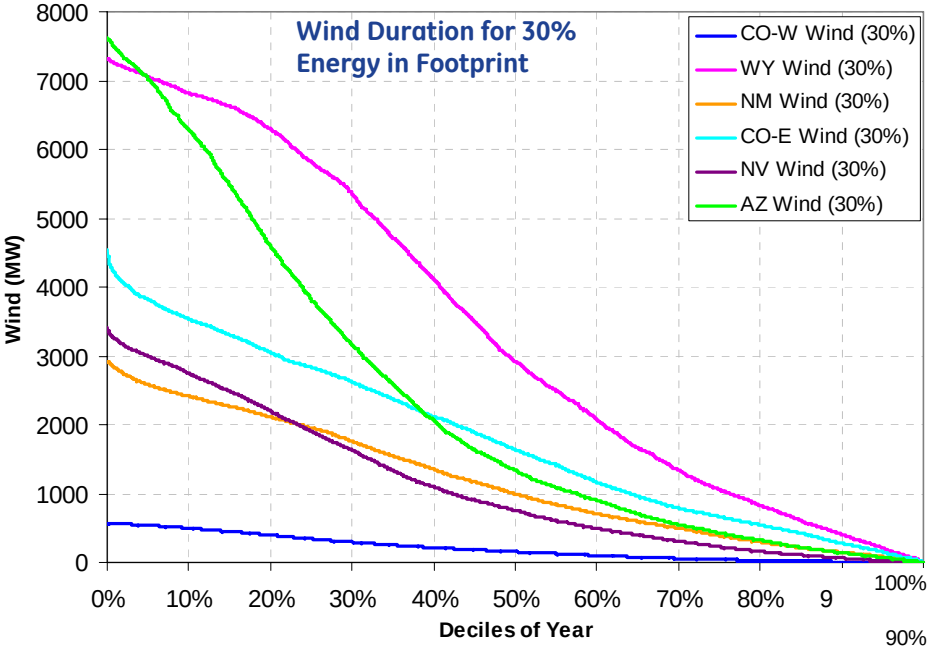
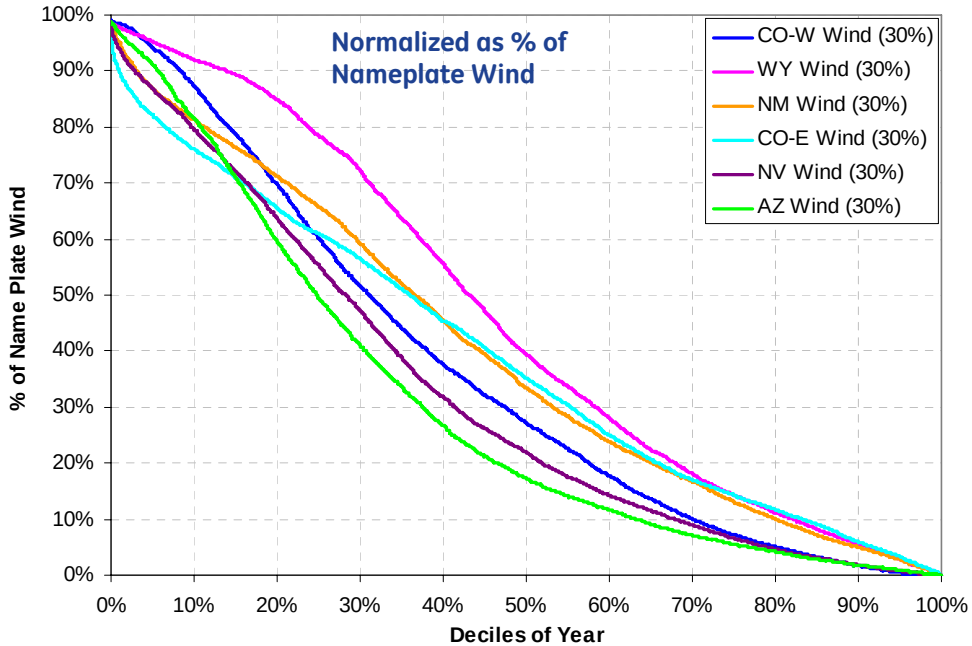
2006 Wind Duration Plots for all Areas

(30% Wind Energy in Footprint – **Local Priority Scenario**)



General flattening of traces for areas with higher quality wind

Area	Max Inst. Pen.
CO-W Wind	75%
WY Wind	286%
NM Wind	110%
CO-E Wind	85%
NV Wind	71%
AZ Wind	101%



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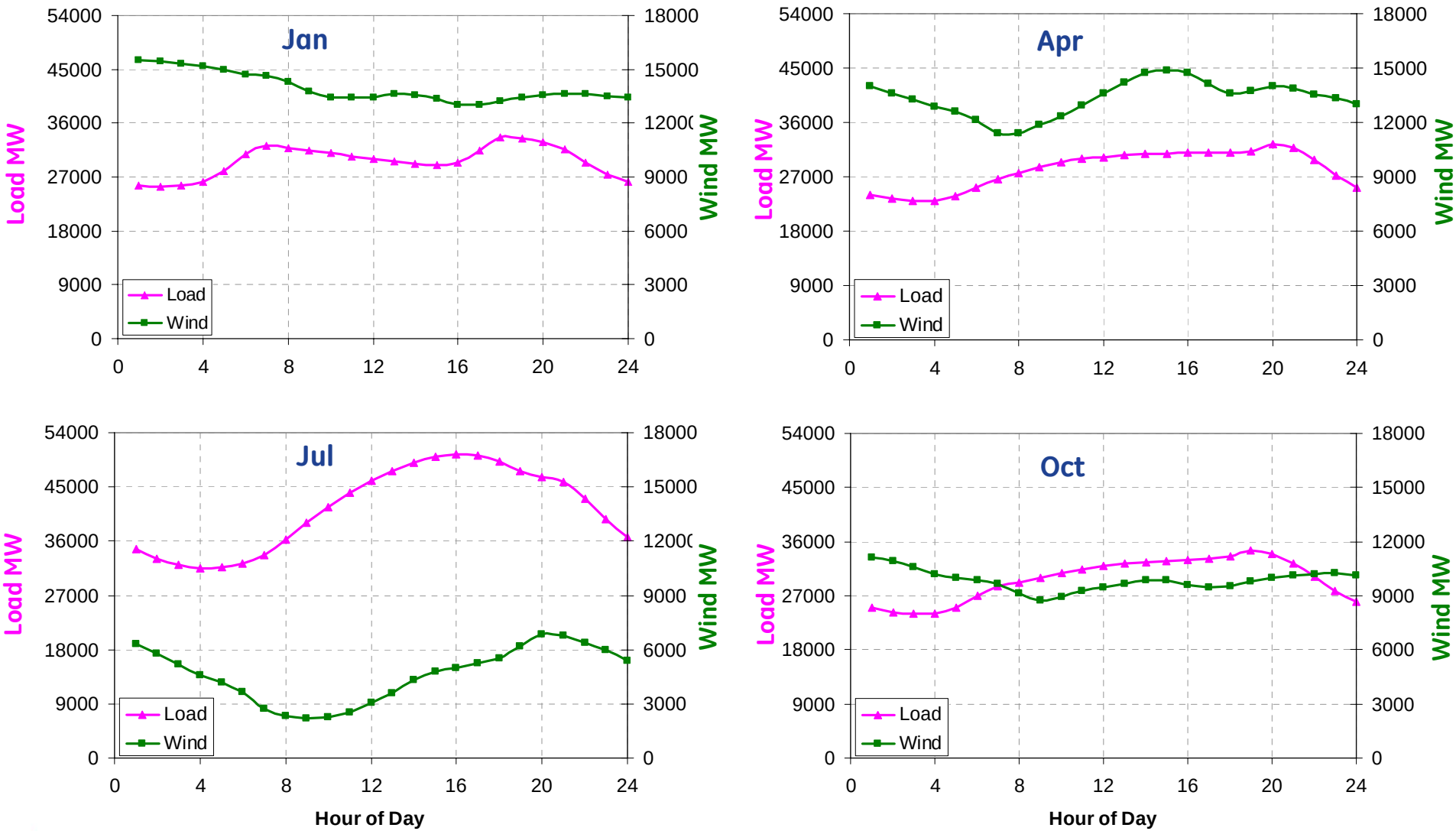
Daily Profiles and Time Series Plots

Study Footprint Load and Wind Average Daily Profiles – IA Scenario
(30% Wind Energy in Footprint)



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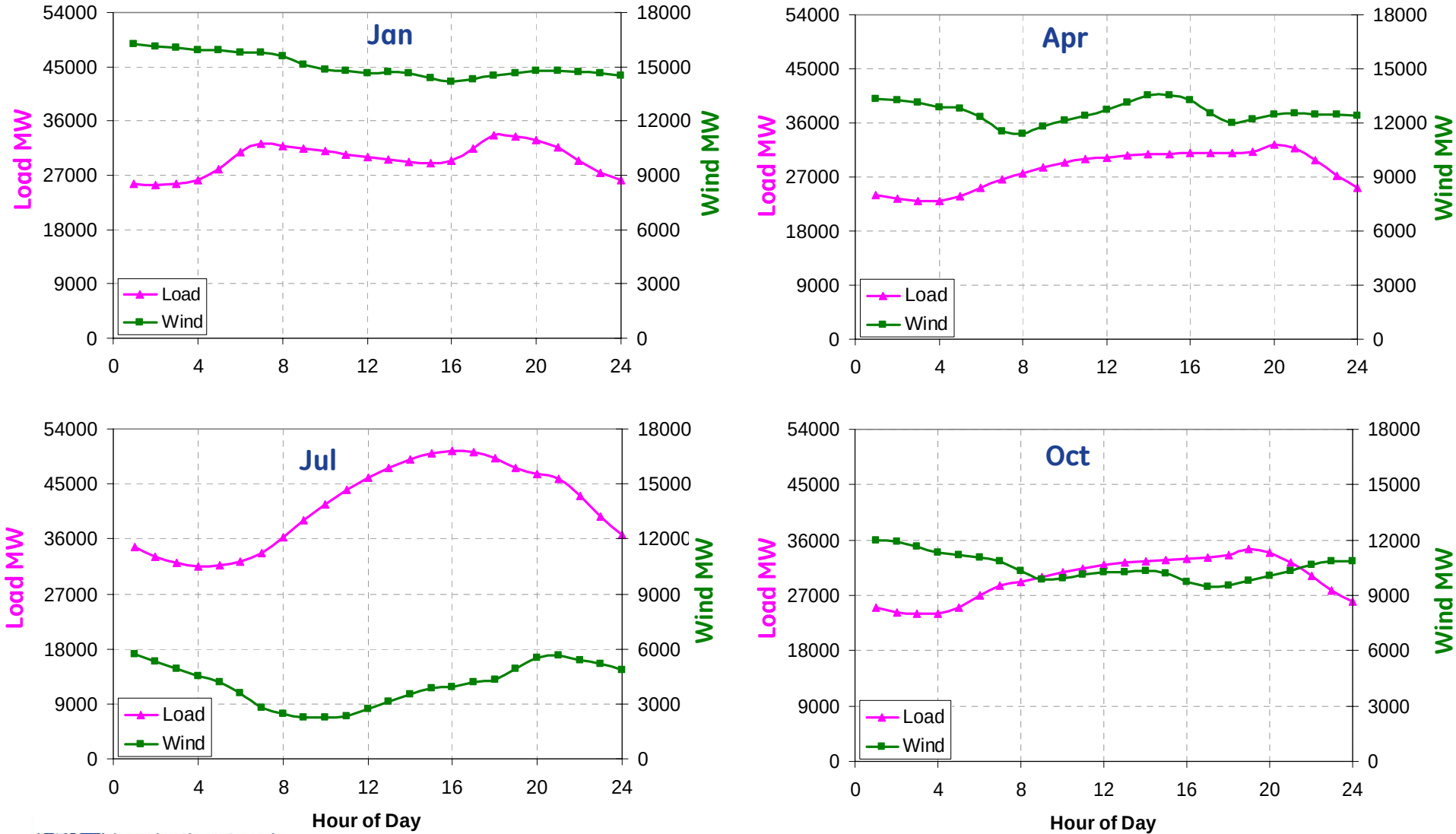
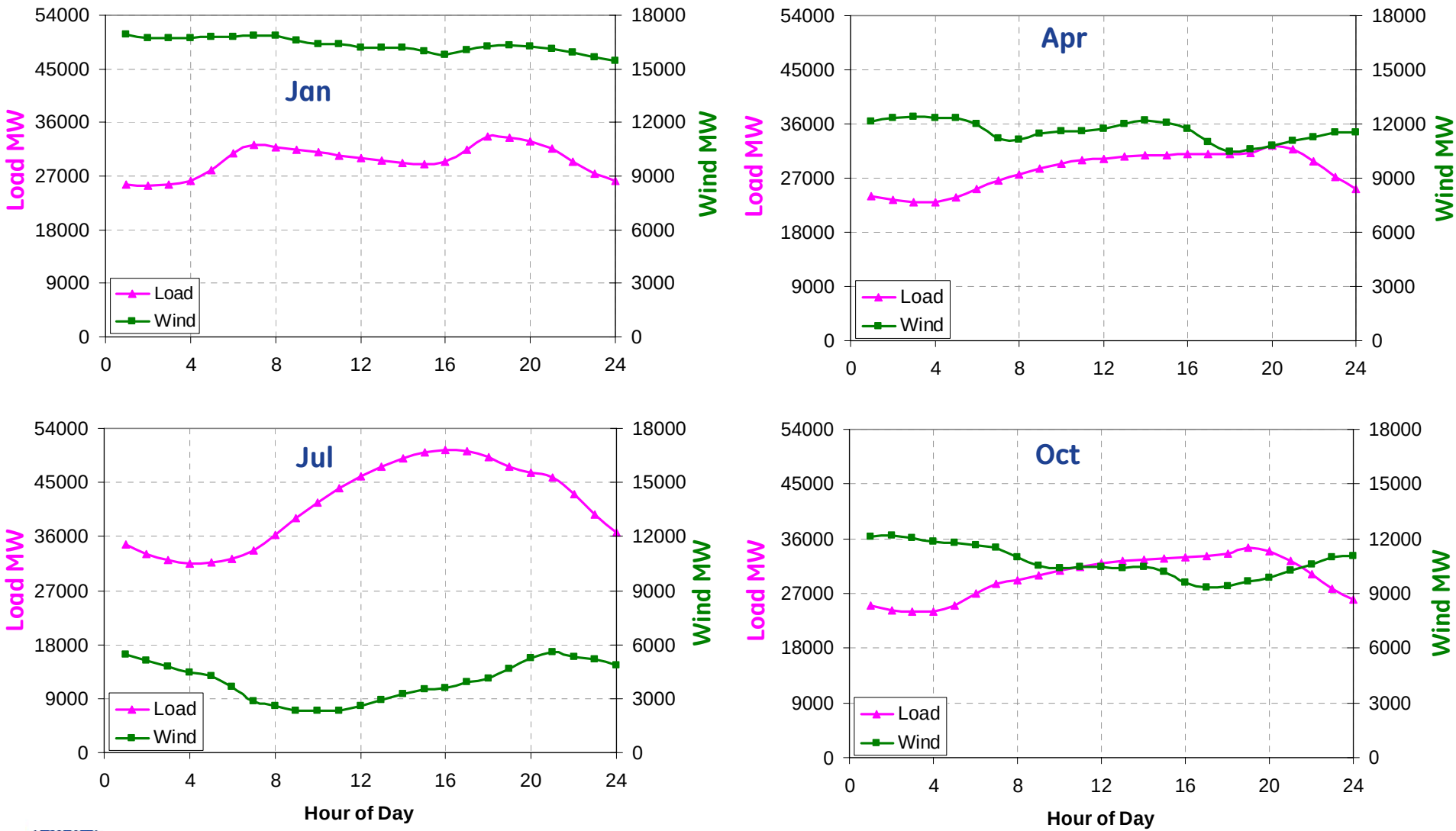
Study Footprint Load and Wind Average Daily Profiles – LP Scenario
(30% Wind Energy in Footprint)



Study Footprint Load and Wind Average Daily Profiles – MP Scenario
(30% Wind Energy in Footprint)



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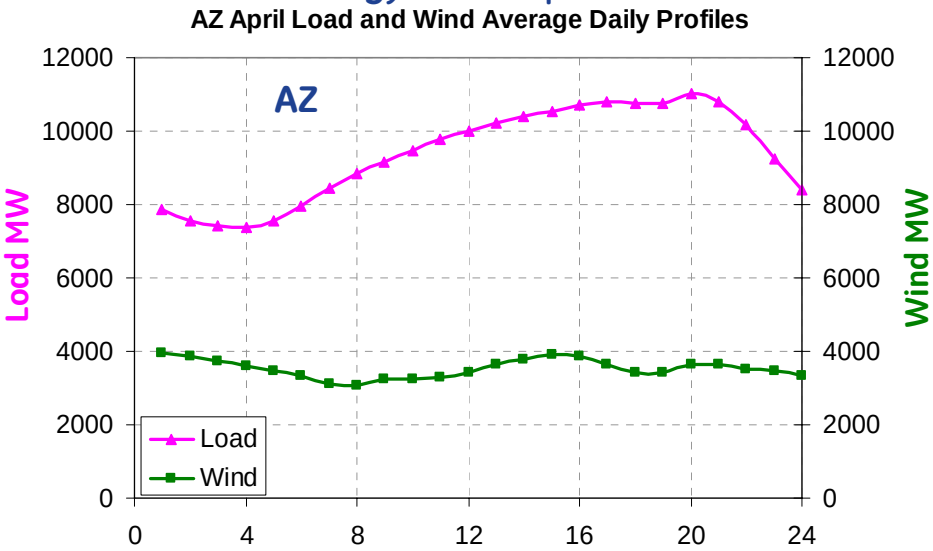
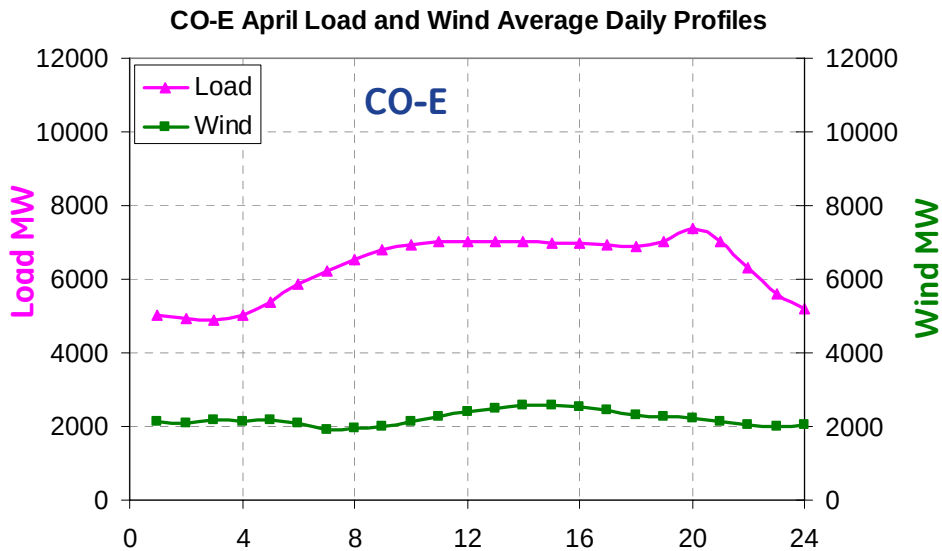
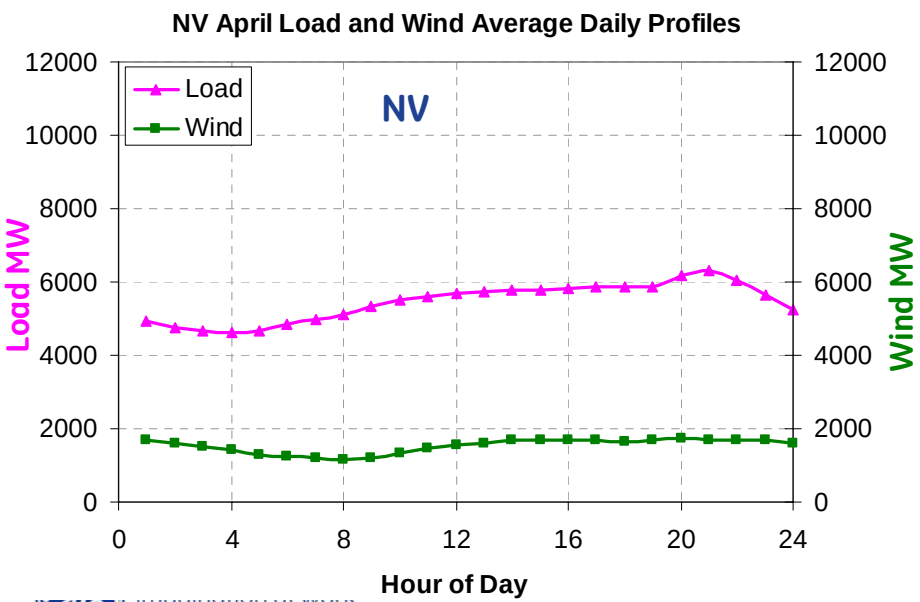
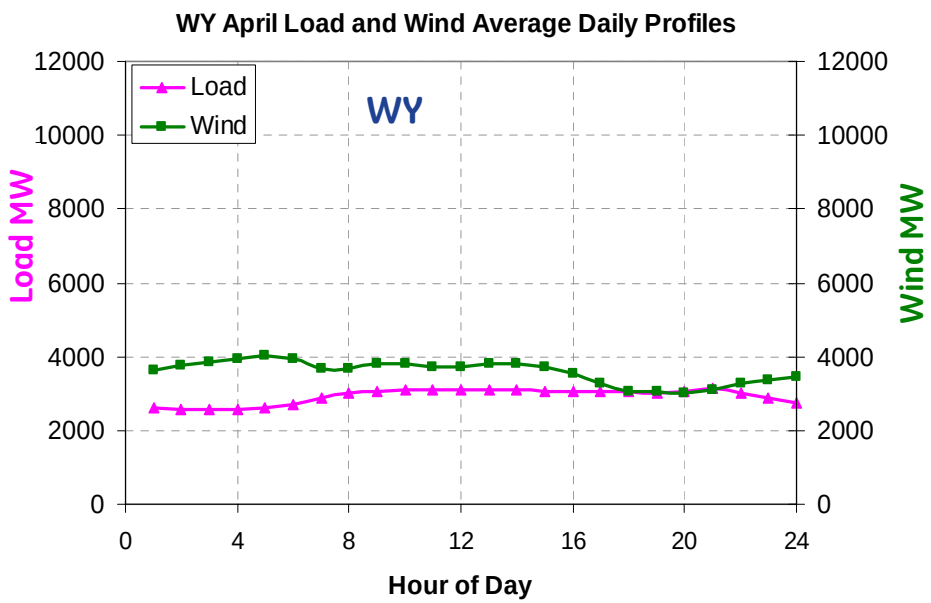
Load and Wind Average Daily Profiles for April 2006 - Selected Areas

(30% Wind Energy in Footprint)

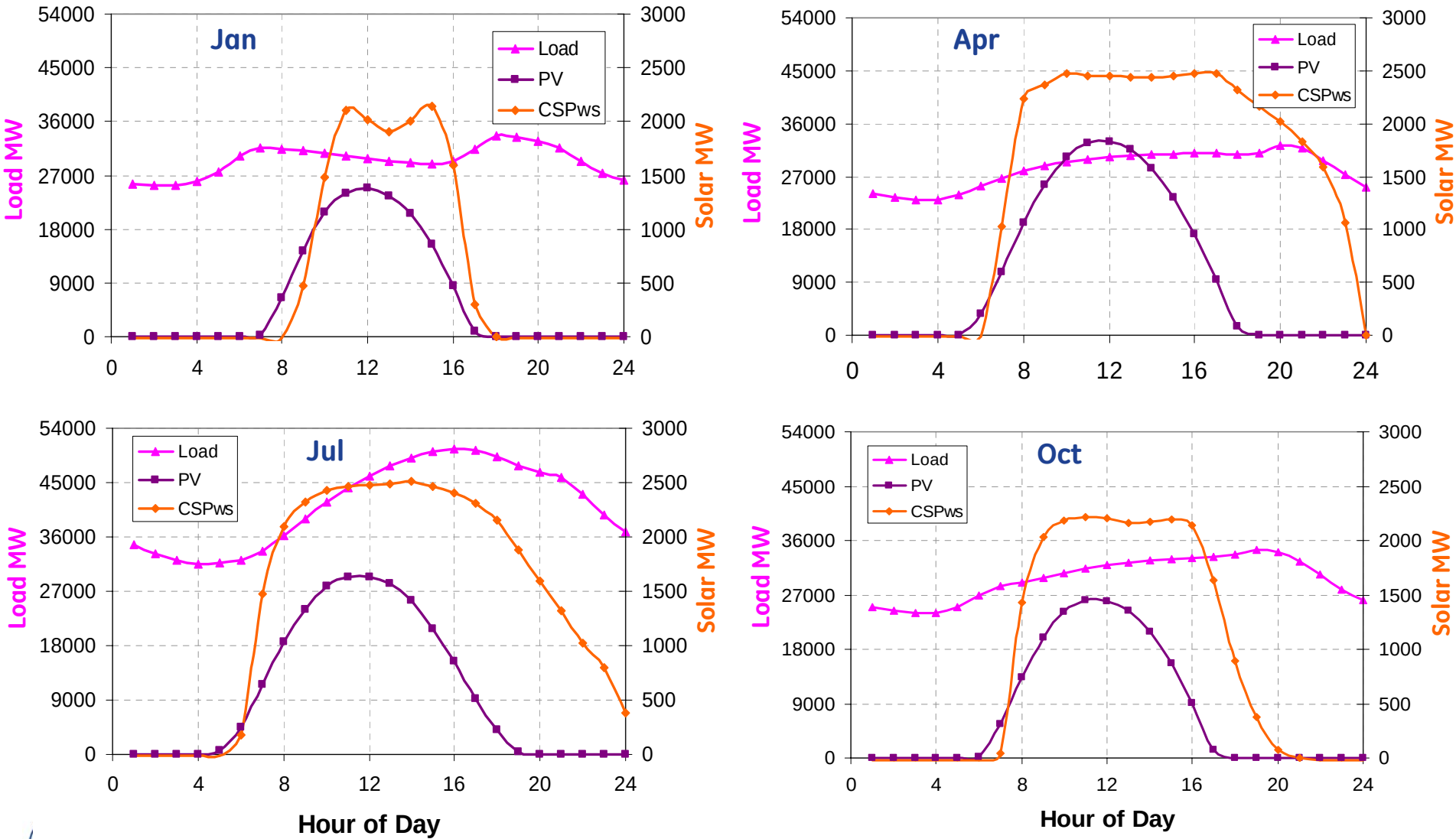






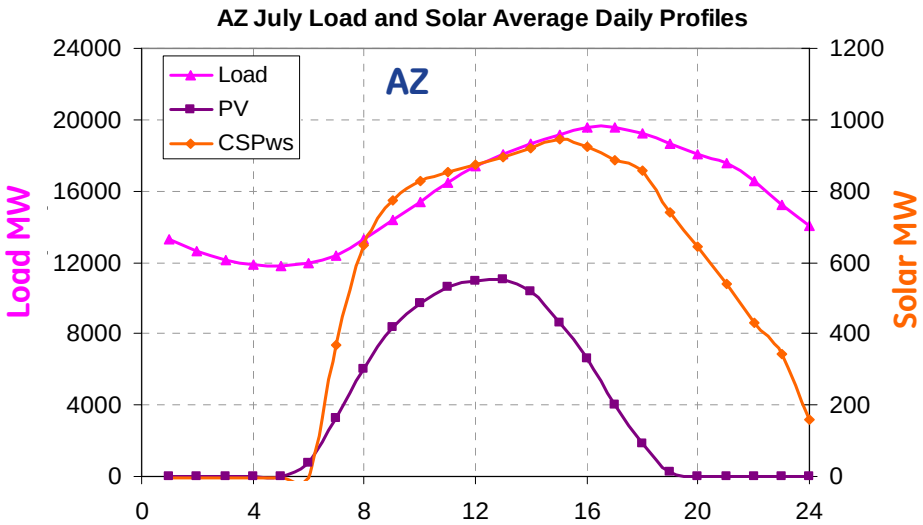


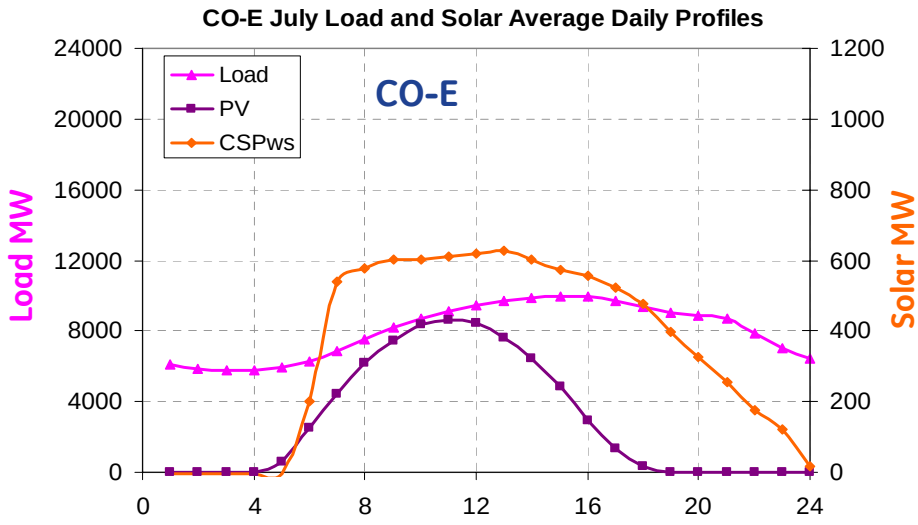
Study Footprint CSPws and PV Average Daily Profiles – LP Scenario
(5% Solar Energy in Footprint)

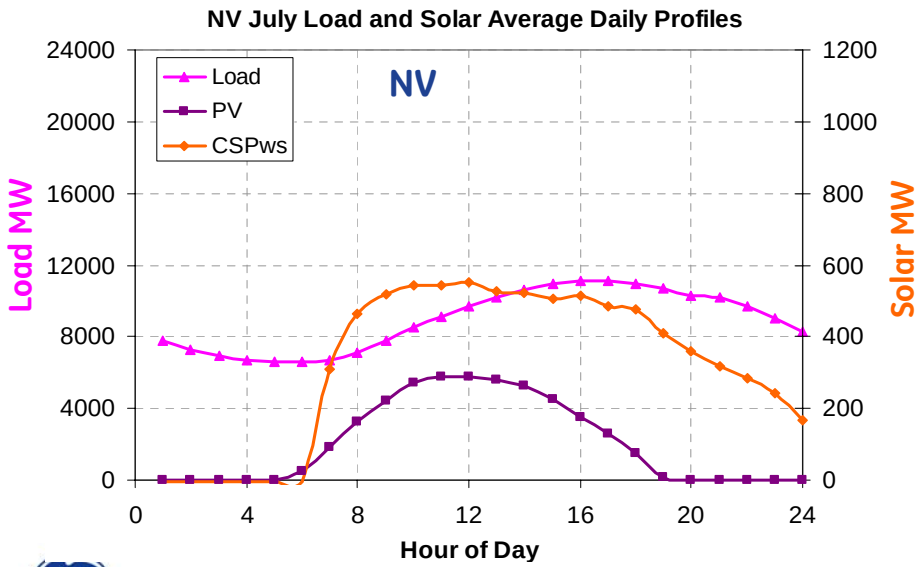


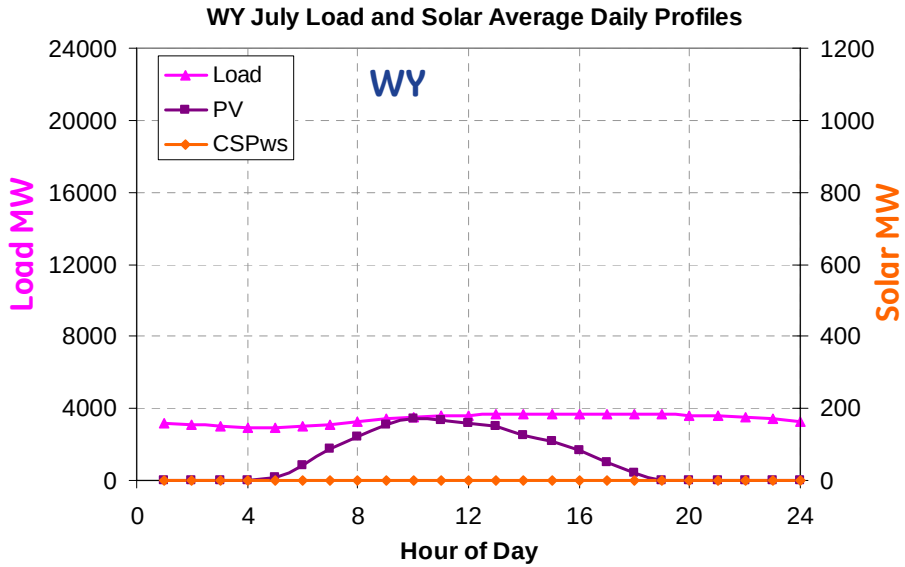
CSPws and PV Average Daily Profiles for Selected Areas - July 2006

(5% Solar Energy in Footprint – LP Scenario)









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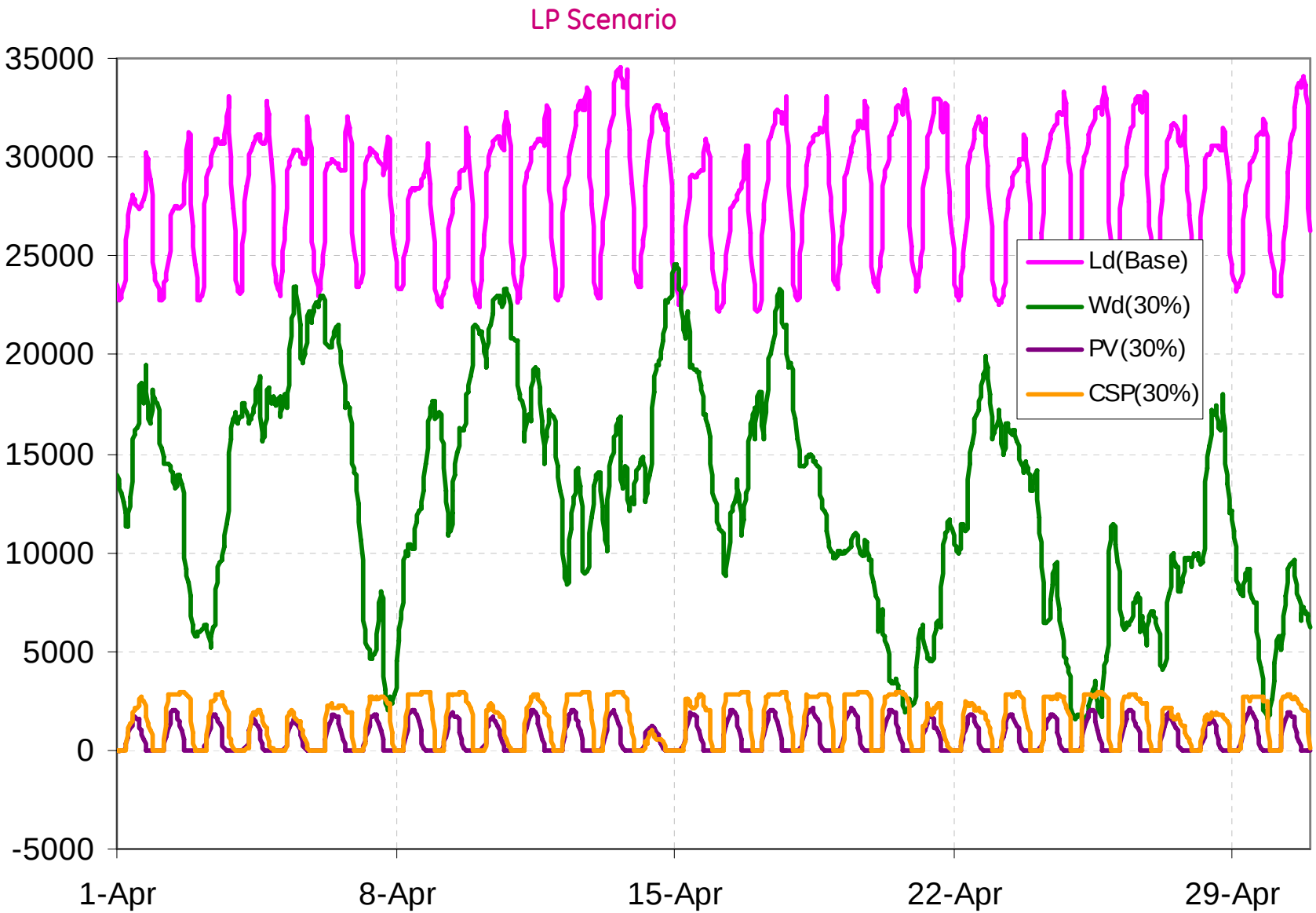
Study Footprint Total Load, Wind and Solar Variation Over Month of April

(30% Wind Energy in Footprint)



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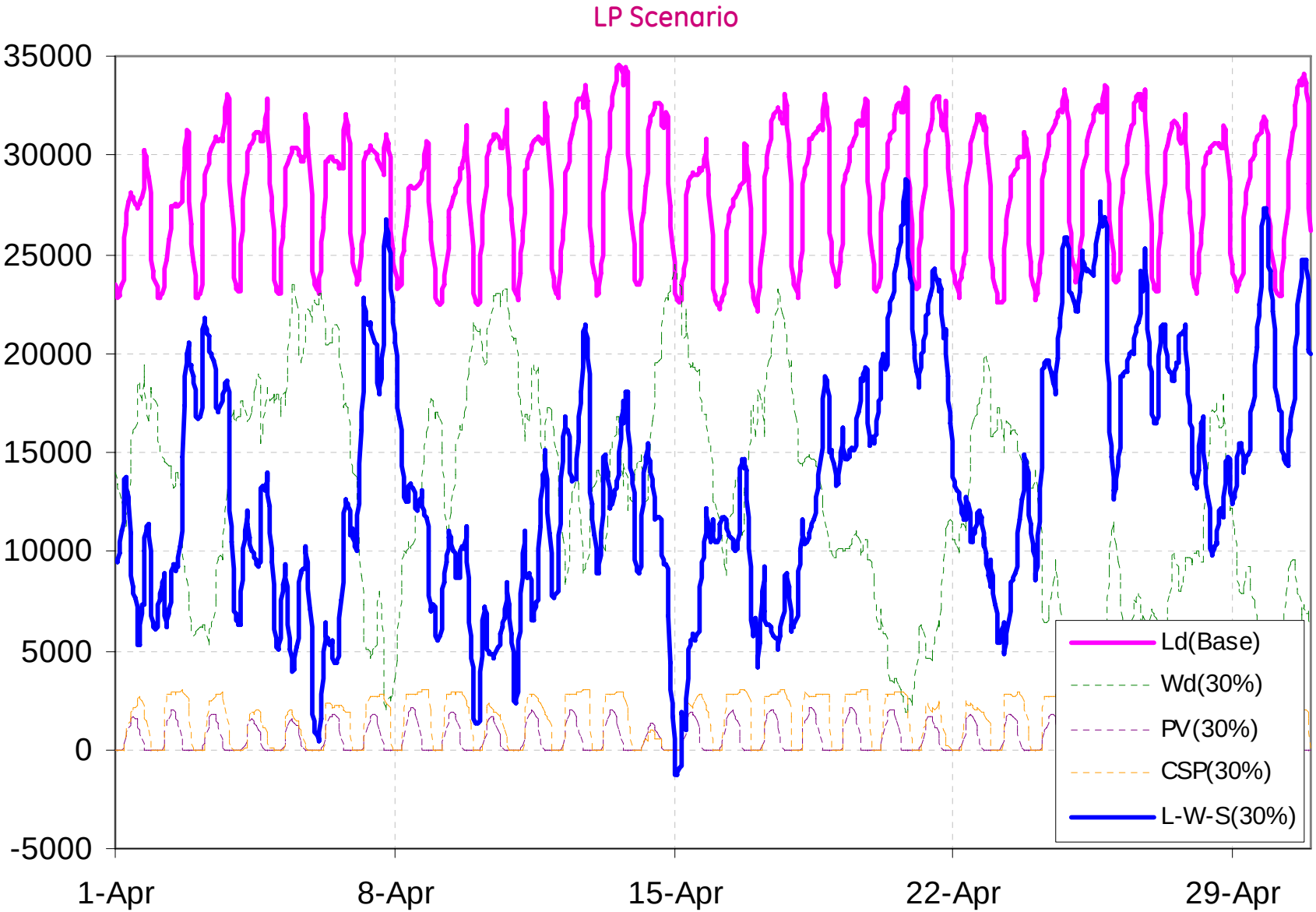
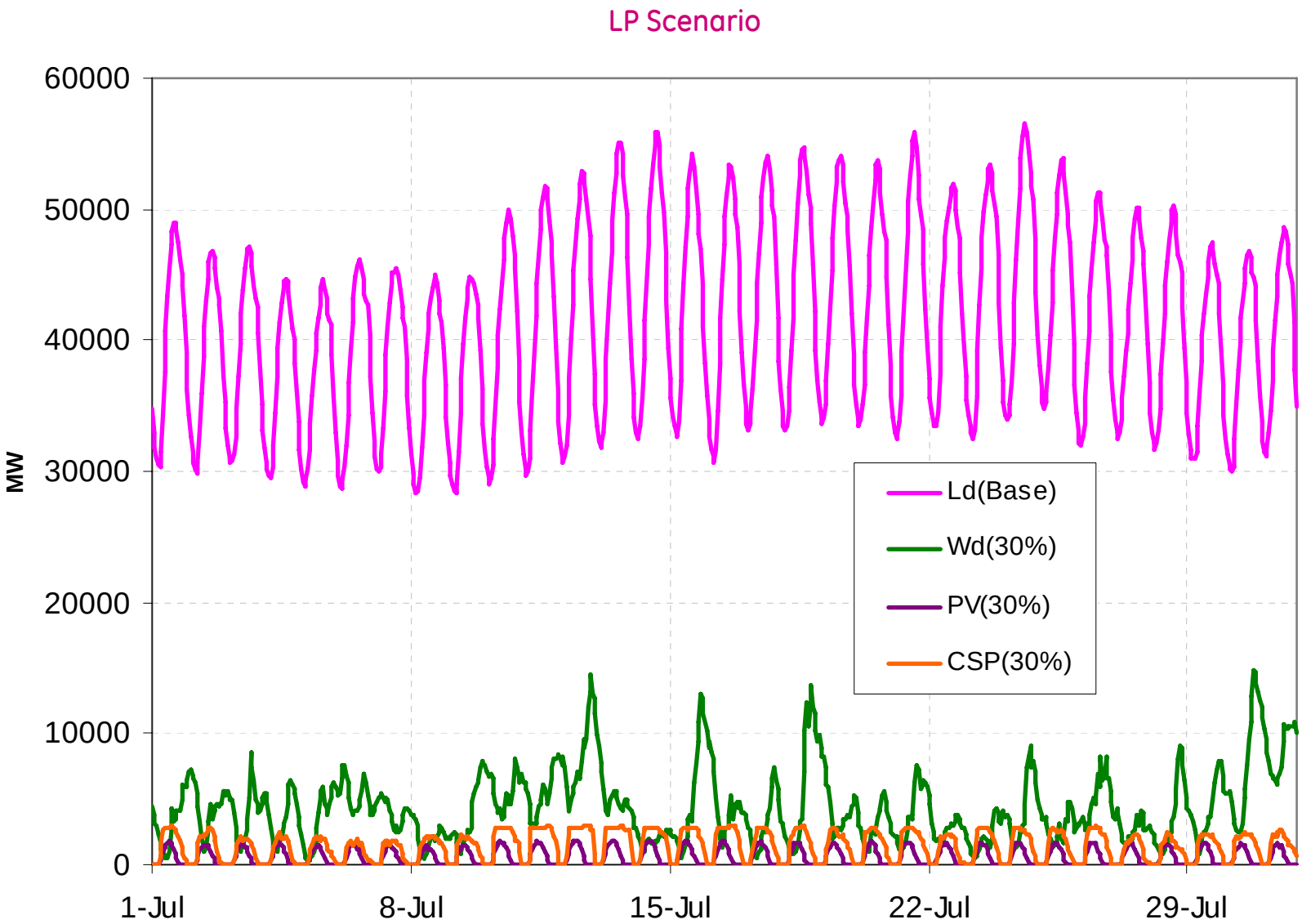
Study Footprint Total Load, Wind and Solar Variation Over Month of April

(30% Wind Energy in Footprint)



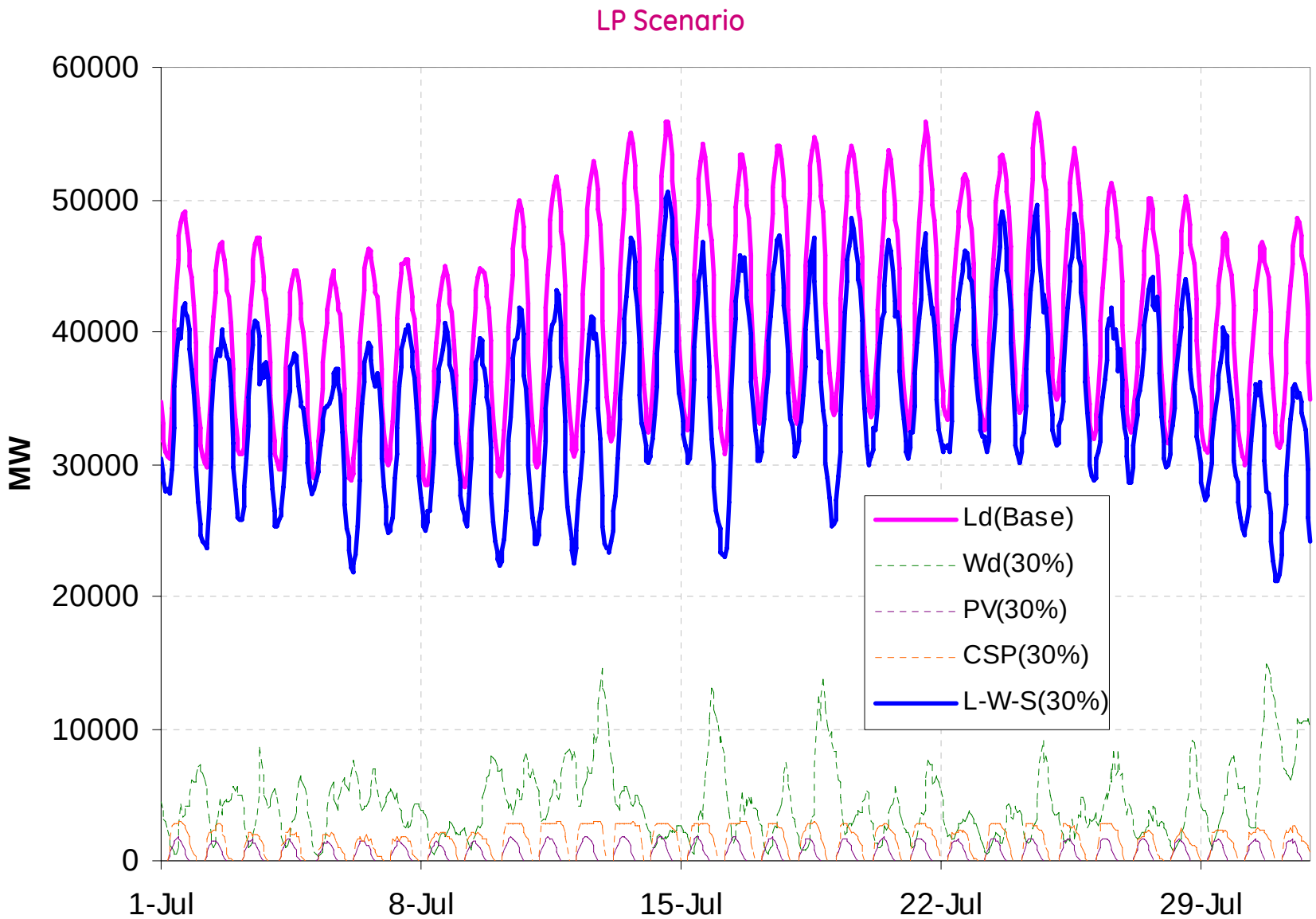
imagination at work

Study Footprint Total Load, Wind and Solar Variation Over Month of July
(30% Wind Energy in Footprint)



imagination at work

Study Footprint Total Load, Wind and Solar Variation Over Month of July
(30% Wind Energy in Footprint)



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