Evaluation of the Kauai Island Utility Co-operative System for Energy Storage Potential

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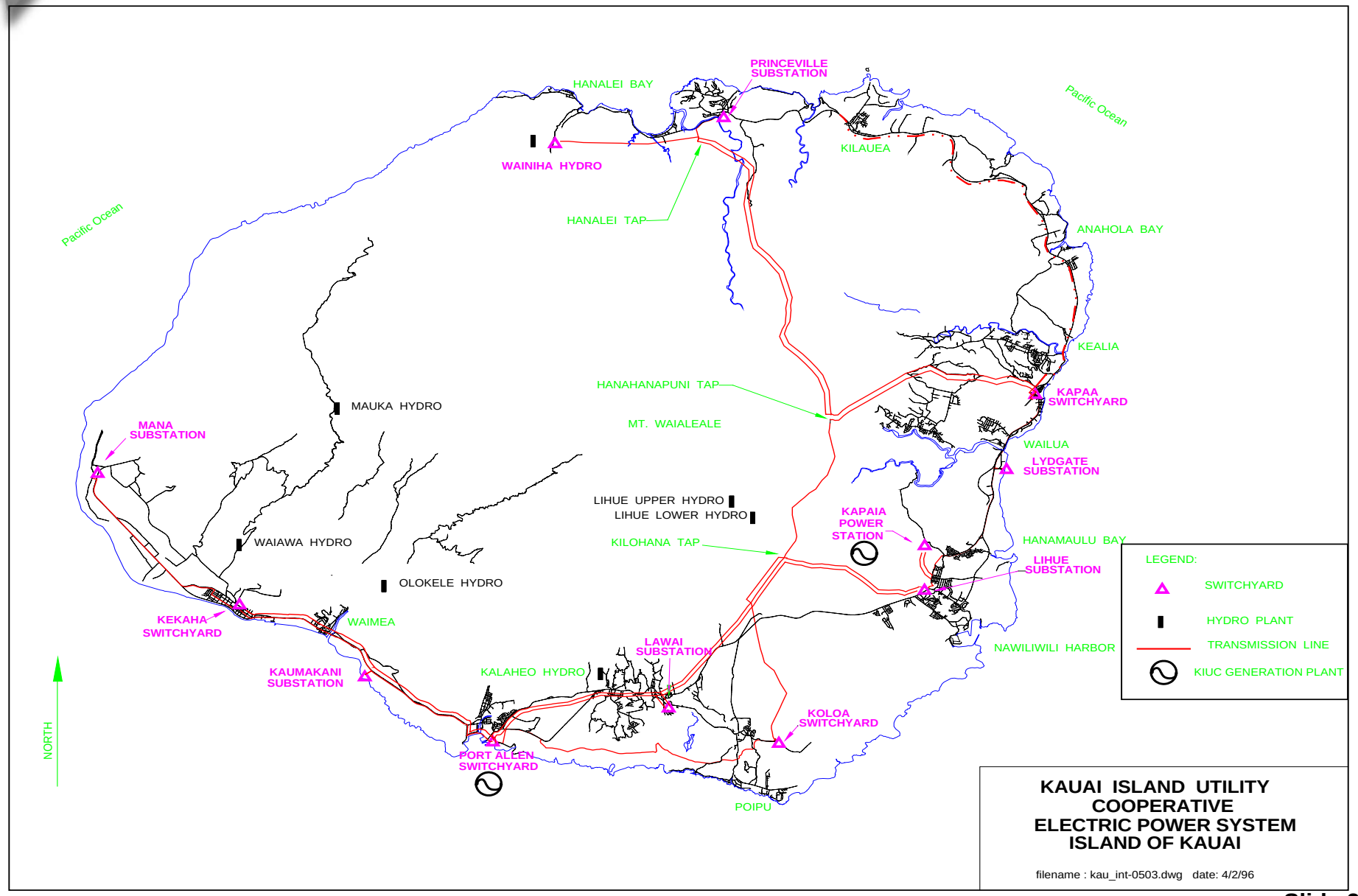


KIUC Port Allen Power Plant

Port Allen Power Plant

Port Allen currently has 12 generating machines capable of producing 96,500 kWs, plus a heat recovery steam generator.

Capacity	Name	Type	Brand	Year in service	Efficiency	#	Individual Capacities
4.0	D1/2	diesel	EMD	1964	34%	2	2.0
10.0	S1	steam turbine	GE	1968	22%	1	10.0
8.2	D3/4/5	diesel	EMD	1968	34%	3	2.7
19.2	GT1	combustion turbine	Hitachi/GE	1973	29%	1	19.2
23.7	GT2	combustion turbine	John Brown/GE	1977	32%	1	23.7
15.7	D6/7	diesel	Wartsila	1989	37%	2	7.9
15.7	D8/9	diesel	Wartsila	1991	37%	2	7.9

Study Objectives

- ***Primary Objective:***
  Identify the generation-side benefits of energy storage and define a storage system that best meets KIUC needs

  Reduce diesel fuel consumption

- ***Secondary Objective:***
  Develop a stability model of the KIUC system based on PSCAD

  Improve system stability with energy storae

Study Dates

- Sandia Energy Storage study commenced September 2005
- Analysis completed June 2006
  - Draft report completed
- Stability study commenced May 2006
  - Performed by Electric Power Systems Consulting Engineers (EPS)

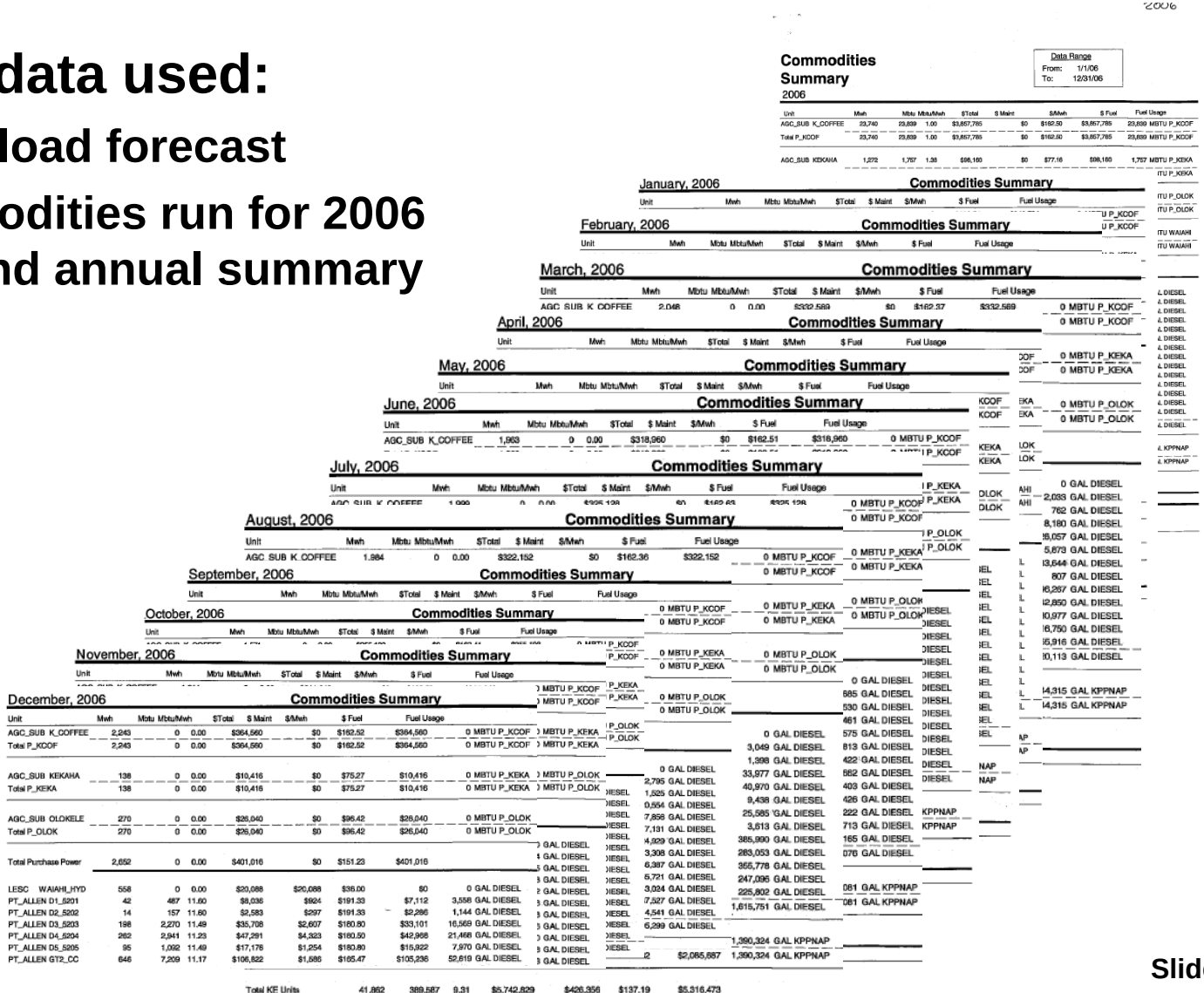
Assumptions for Storage Analysis

- ***Storage system size: 4 MW / 16 MWh***
  - ***Match nameplate ratings of EMD's at Port Allen***
- **Simplifying assumption for initial analysis**
  - **Storage system is completely charged/discharged daily**
  - **Charged ~ 0200 – 0600 hrs; discharged ~ 1700 – 2100 hrs**
- **Three roundtrip efficiencies considered:**
  - **85%, 80% and 70%**

Peak Shaving Analysis

KIUC system data used:

- 2006 hourly load forecast
- KIUC Commodities run for 2006
  - monthly and annual summary



Commodities Summary
2006

Data Range
From: 1/1/06
To: 12/31/06

Unit	Mwh	Mbtu	Mbtu/Mwh	$Total	$ Maint	$/Mwh	$ Fuel	Fuel Usage
AGC_SUB K_COFFEE	23,740	23,839	1.00	$3,857,785		$0	$162.50	$3,857,785 23,839 MBTU P_KCOF
Total P_KCOF	23,740	23,839	1.00	$3,857,785		$0	$162.50	$3,857,785 23,839 MBTU P_KCOF
AGC_SUB KEKAHA	1,272	1,757	1.38	$98,160		$0	$77.16	$98,160 1,757 MBTU P_KEKA

January, 2006 Commodities Summary

February, 2006 Commodities Summary

March, 2006 Commodities Summary

Unit	Mwh	Mbtu	Mbtu/Mwh	$Total	$ Maint	$/Mwh	$ Fuel	Fuel Usage
AGC_SUB K_COFFEE	2,048	0	0.00	$332,589		$0	$162.37	$332,589 0 MBTU P_KCOF

April, 2006 Commodities Summary

May, 2006 Commodities Summary

June, 2006 Commodities Summary

Unit	Mwh	Mbtu	Mbtu/Mwh	$Total	$ Maint	$/Mwh	$ Fuel	Fuel Usage
AGC_SUB K_COFFEE	1,953	0	0.00	$318,960		$0	$162.51	$318,960 0 MBTU P_KCOF

July, 2006 Commodities Summary

August, 2006 Commodities Summary

Unit	Mwh	Mbtu	Mbtu/Mwh	$Total	$ Maint	$/Mwh	$ Fuel	Fuel Usage
AGC_SUB K_COFFEE	1,984	0	0.00	$322,152		$0	$162.36	$322,152 0 MBTU P_KCOF

September, 2006 Commodities Summary

October, 2006 Commodities Summary

November, 2006 Commodities Summary

December, 2006 Commodities Summary

Unit	Mwh	Mbtu	Mbtu/Mwh	$Total	$ Maint	$/Mwh	$ Fuel	Fuel Usage
AGC_SUB K_COFFEE	2,243	0	0.00	$364,560		$0	$162.52	$364,560 0 MBTU P_KCOF
Total P_KCOF	2,243	0	0.00	$364,560		$0	$162.52	$364,560 0 MBTU P_KCOF
AGC_SUB KEKAHA	138	0	0.00	$10,416		$0	$75.27	$10,416 0 MBTU P_KEKA
Total P_KEKA	138	0	0.00	$10,416		$0	$75.27	$10,416 0 MBTU P_KEKA
AGC_SUB OLOKELE	270	0	0.00	$26,040		$0	$96.42	$26,040 0 MBTU P_OLOK
Total P_OLOK	270	0	0.00	$26,040		$0	$96.42	$26,040 0 MBTU P_OLOK
Total Purchase Power	2,652	0	0.00	$401,016		$0	$151.23	$401,016
LESC WAIAHI_HYD	558	0	0.00	$20,088	$20,088	$36.00	$0	0 GAL DIESEL
PT_ALLEN D1_5201	42	487	11.60	$8,036	$924	$191.33	$7,112	3,558 GAL DIESEL
PT_ALLEN D2_5202	14	157	11.60	$2,583	$297	$191.33	$2,286	1,144 GAL DIESEL
PT_ALLEN D3_5203	198	2,270	11.49	$35,708	$2,607	$180.80	$33,101	16,569 GAL DIESEL
PT_ALLEN D4_5204	262	2,941	11.23	$47,291	$4,323	$180.50	$42,968	21,466 GAL DIESEL
PT_ALLEN D5_5205	95	1,092	11.49	$17,176	$1,254	$180.80	$15,922	7,970 GAL DIESEL
PT_ALLEN GT2_CC	646	7,209	11.17	$106,822	$1,586	$165.47	$105,236	52,619 GAL DIESEL
Total KE Units	41,962	389,587	9.31	$5,742,829	$426,356	$137.19	$5,316,473	

Typical Daily Load Profiles - 2006

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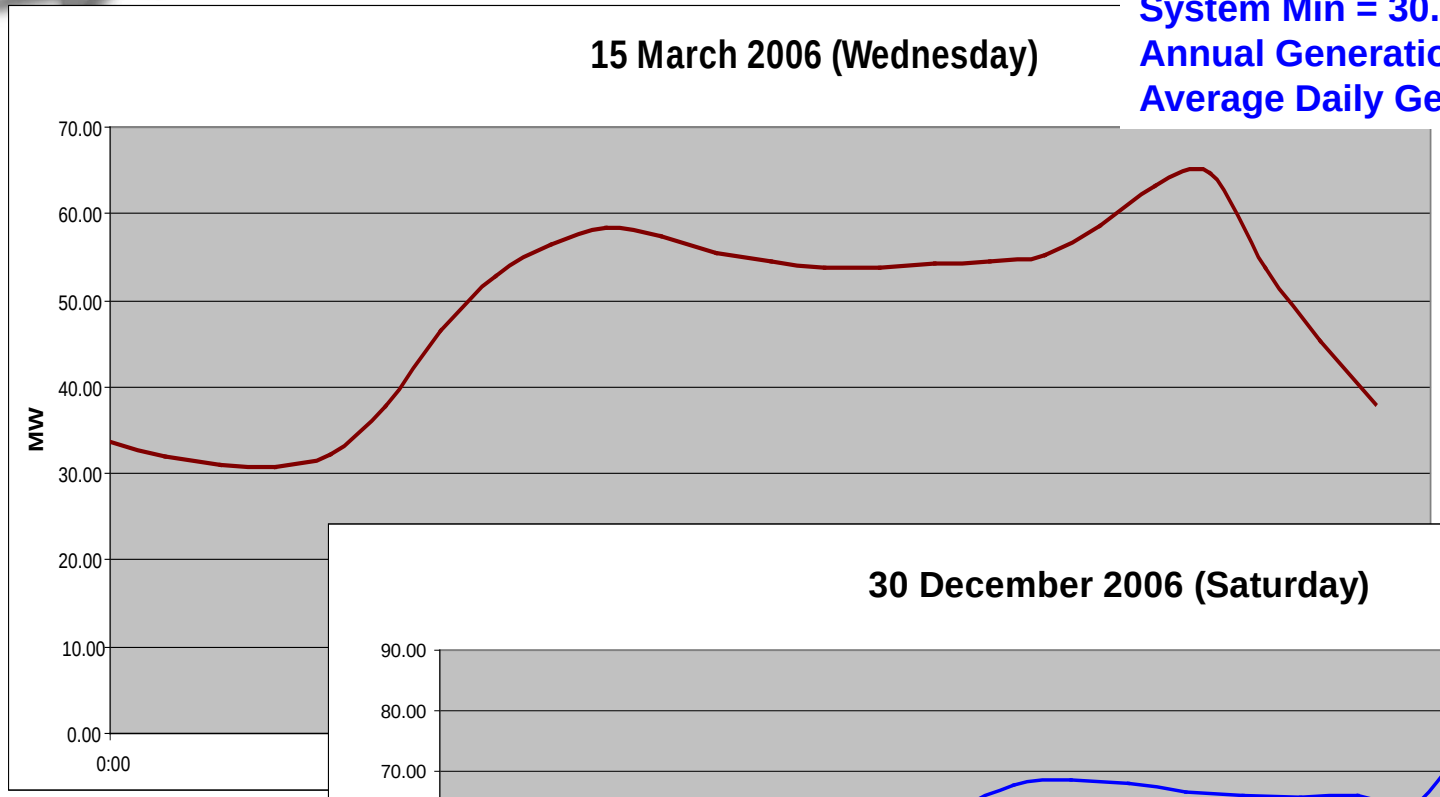
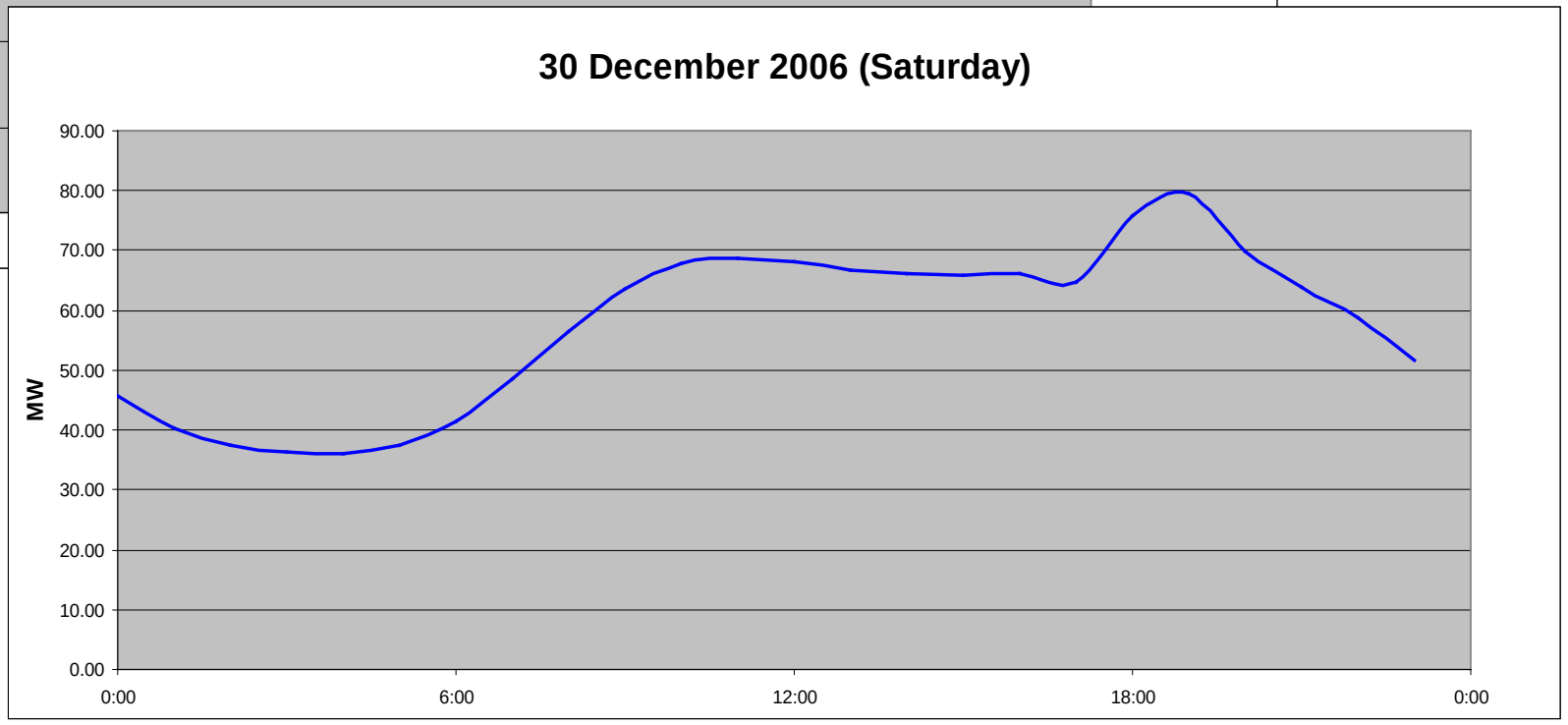
System Peak = 79.58 MW (December)
System Min = 30.46 MW (March)
Annual Generation = 481,000 MWh
Average Daily Generation = 1,321 MWh

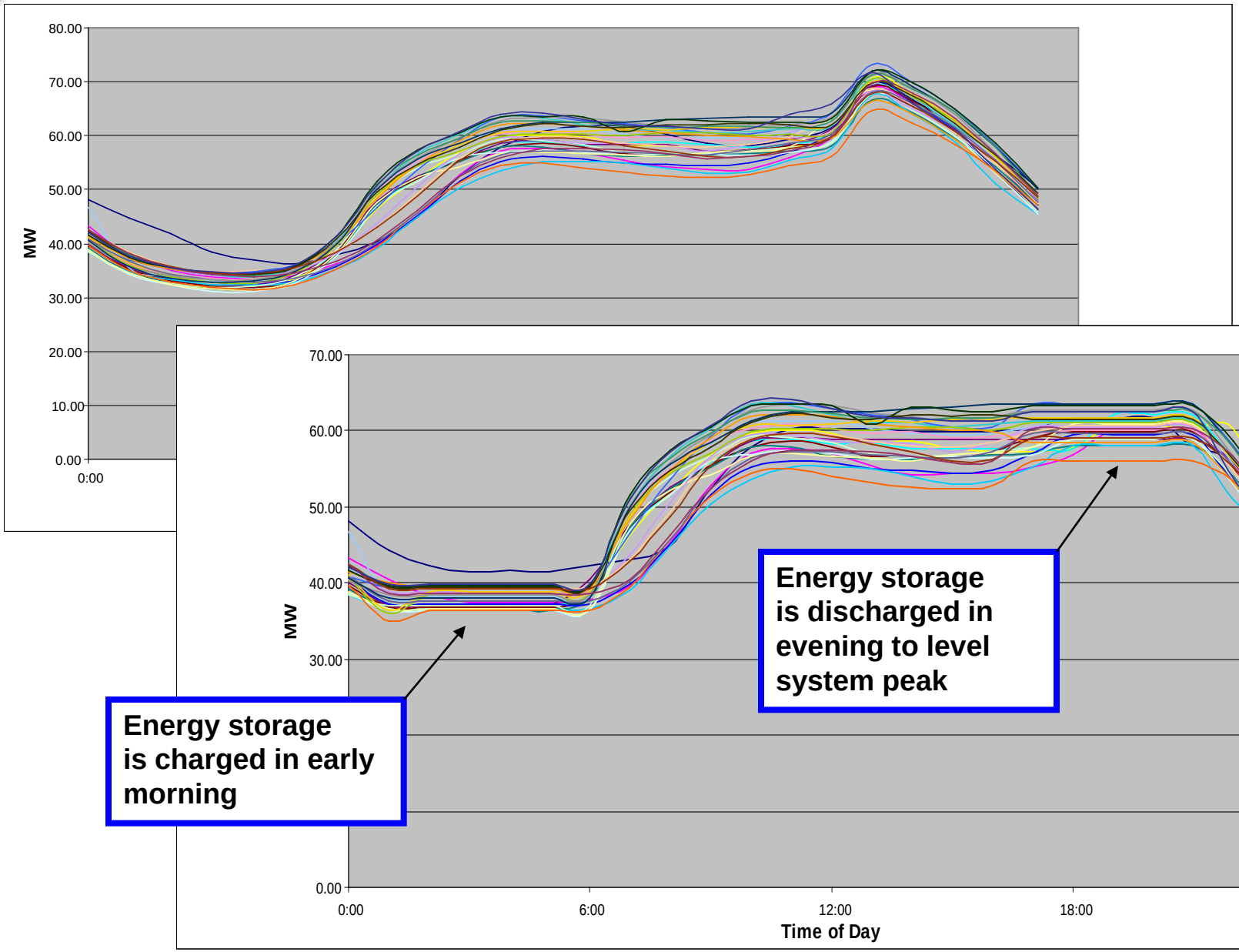




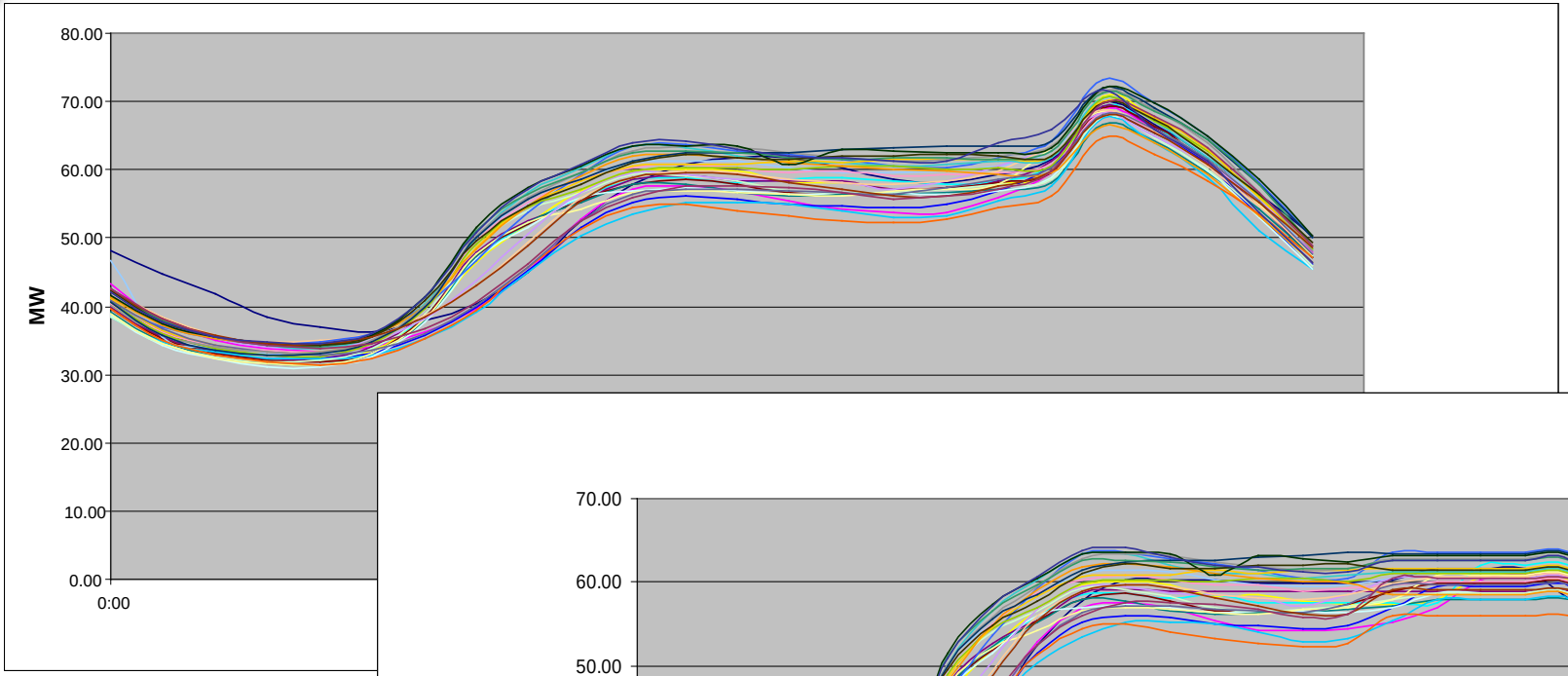
Peak Shaving Analysis – Cont'd

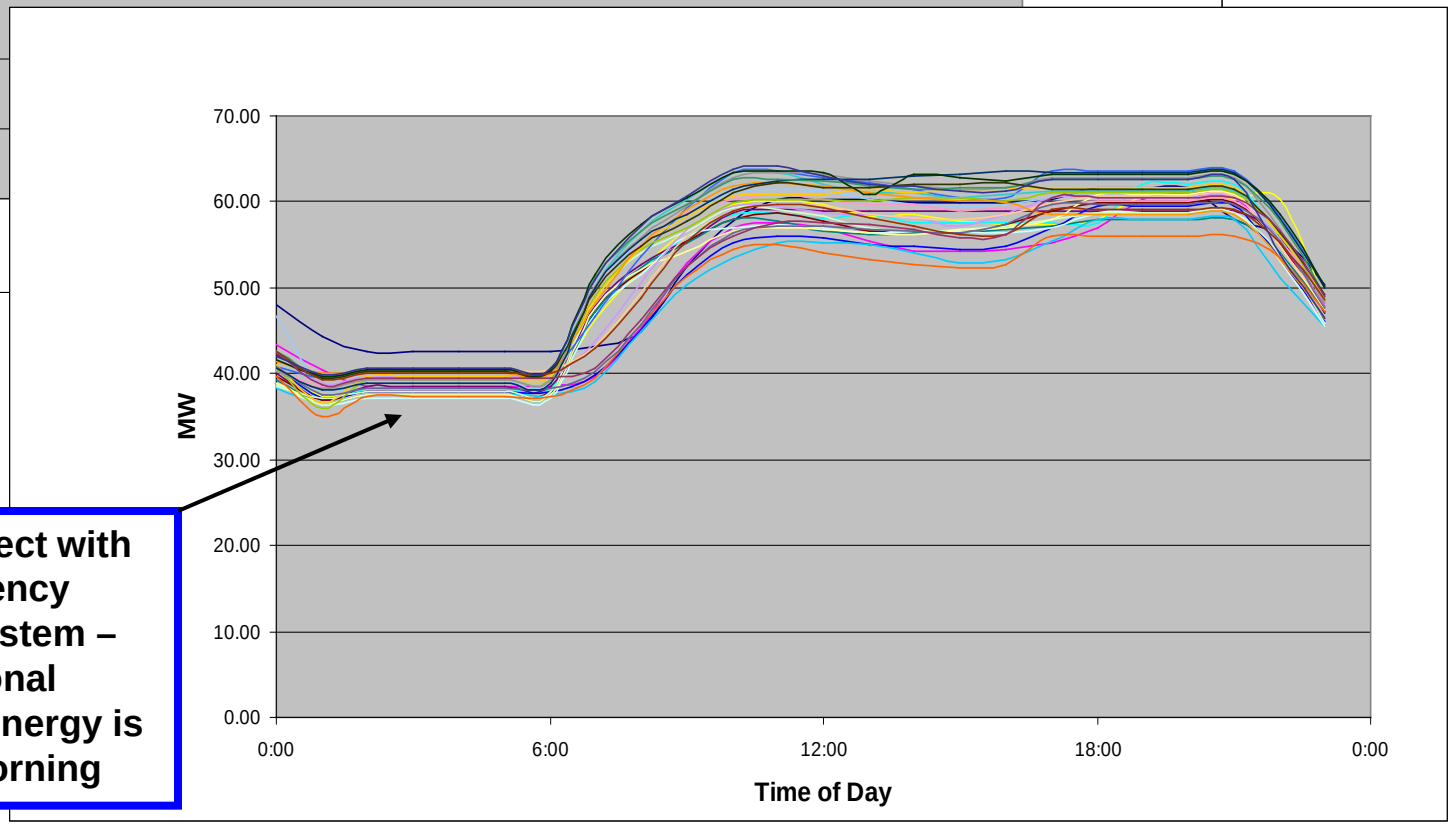
16 Mwh of energy storage levels daily KIUC system peak - shown on following plots for both a 85% and 70% roundtrip efficiency storage system

Daily Load Profiles for January 2006
16 MWh Energy Storage – 85% Efficiency Storage



Daily Load Profiles for January 2006
16 MWh Energy Storage – 70% Efficiency Storage





Similar affect with 70% efficiency storage system – but additional charging energy is used in morning

Peak Shaving Analysis – Cont'd

Result shows a net *reduction* in fuel usage and maintenance costs for KIUC system

- **Kapaia fuel (naptha) usage increases with corresponding increase in maintenance costs**
- **EMD fuel (diesel) usage and maintenance costs are reduced**

- **Aggregate annual savings are tabulated below:**

	Diesel Maintenance Cost	Diesel Fuel Cost	KPA Maintenance Cost	KPA Fuel Cost	Net Savings
85% Storage Efficiency	$2,882,283	$32,202,627	$1,912,872	$24,006,818	$61,004,600
Without Storage	$2,942,087	$32,456,405	$1,901,483	$23,838,446	$61,138,421
	-$59,804	-$253,778	11,389	168,372	-$133,821

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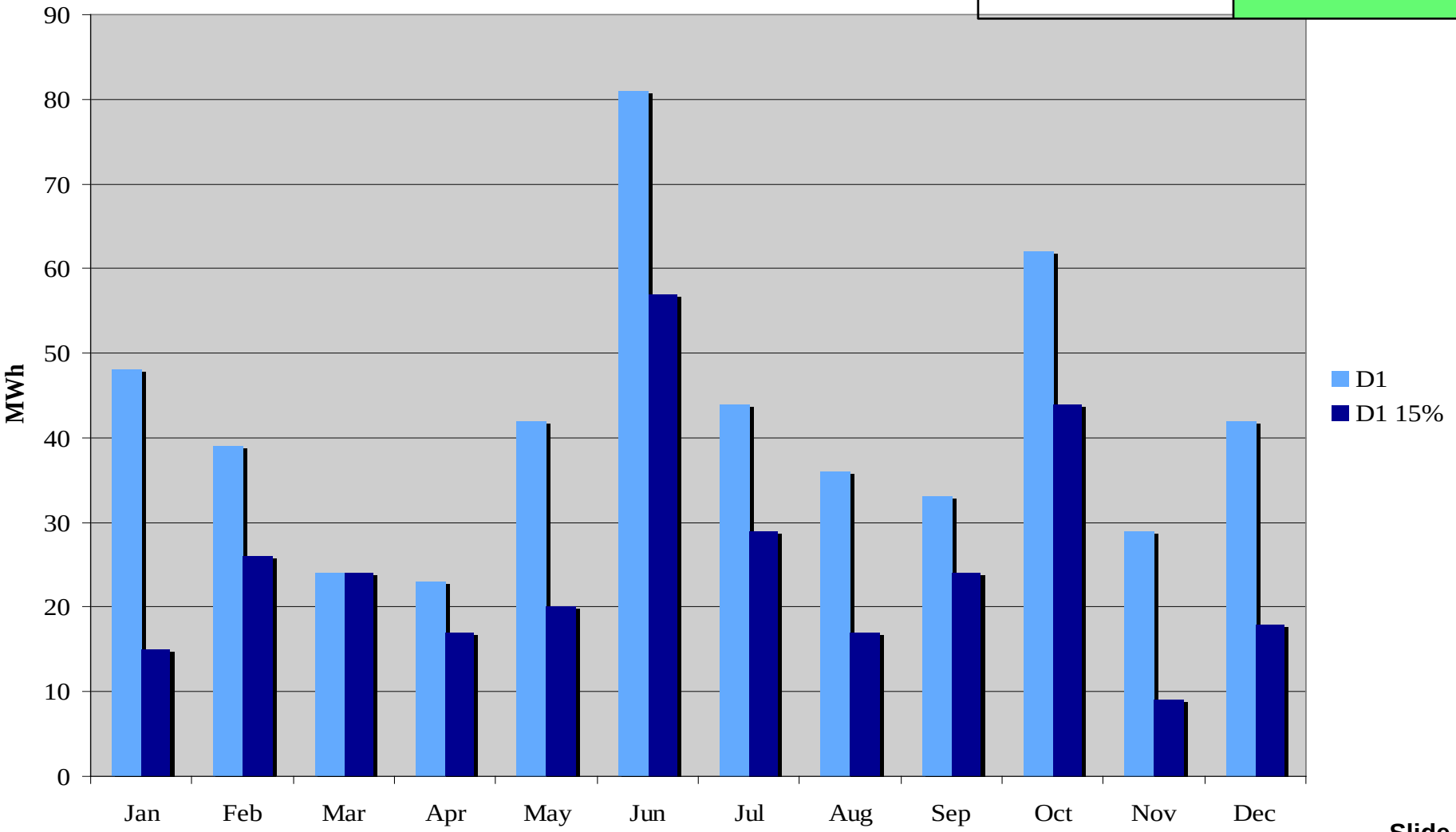
W/O Storage	503 MWh
W/ Storage	300 MWh
Net Decrease	203 MWh
% Decrease	40 %

D1 With and Without Storage



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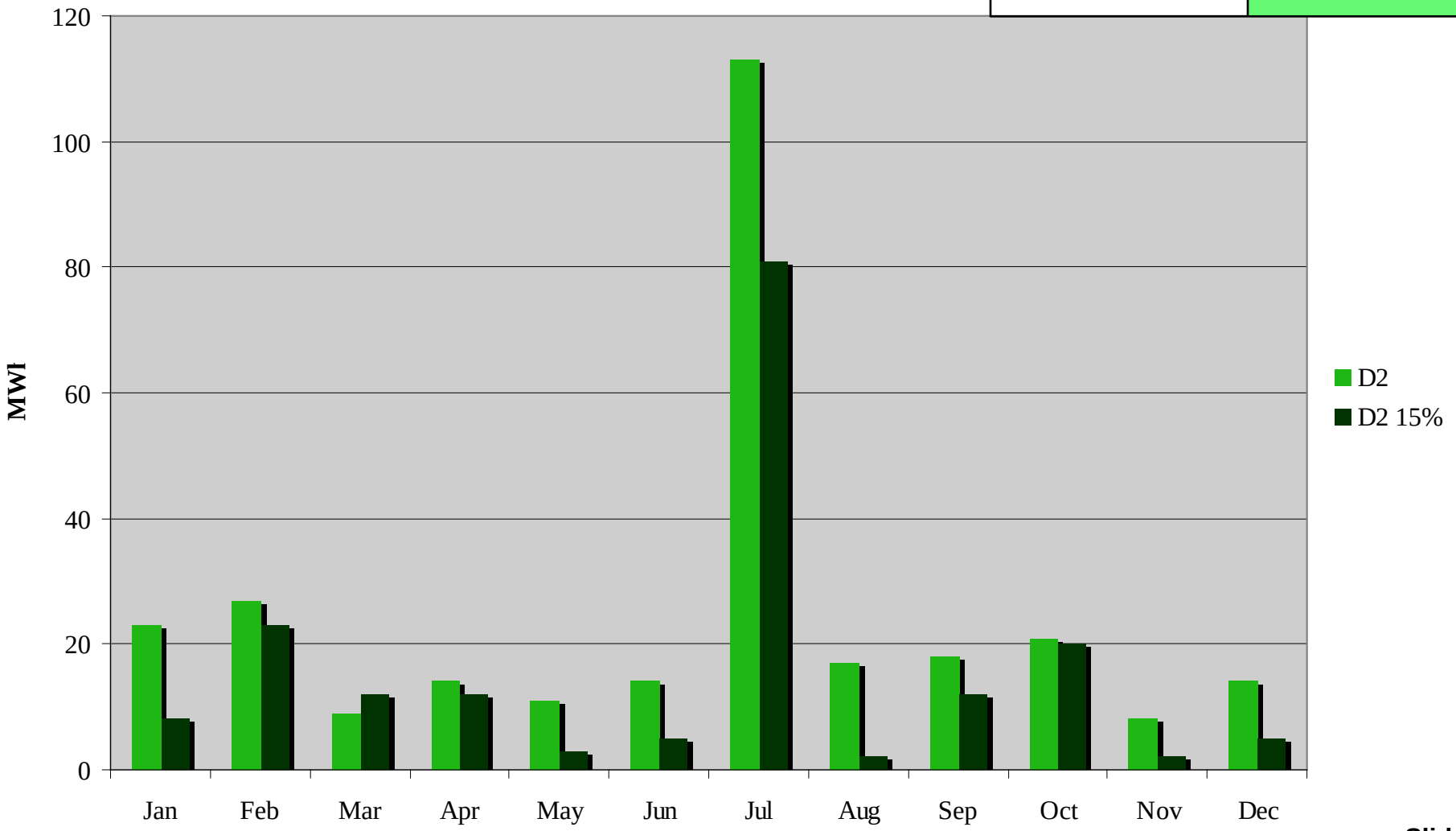
W/O Storage	289 MWh
W/ Storage	185 MWh
Net Decrease	104 MWh
% Decrease	36 %

D2 Generation - 2006



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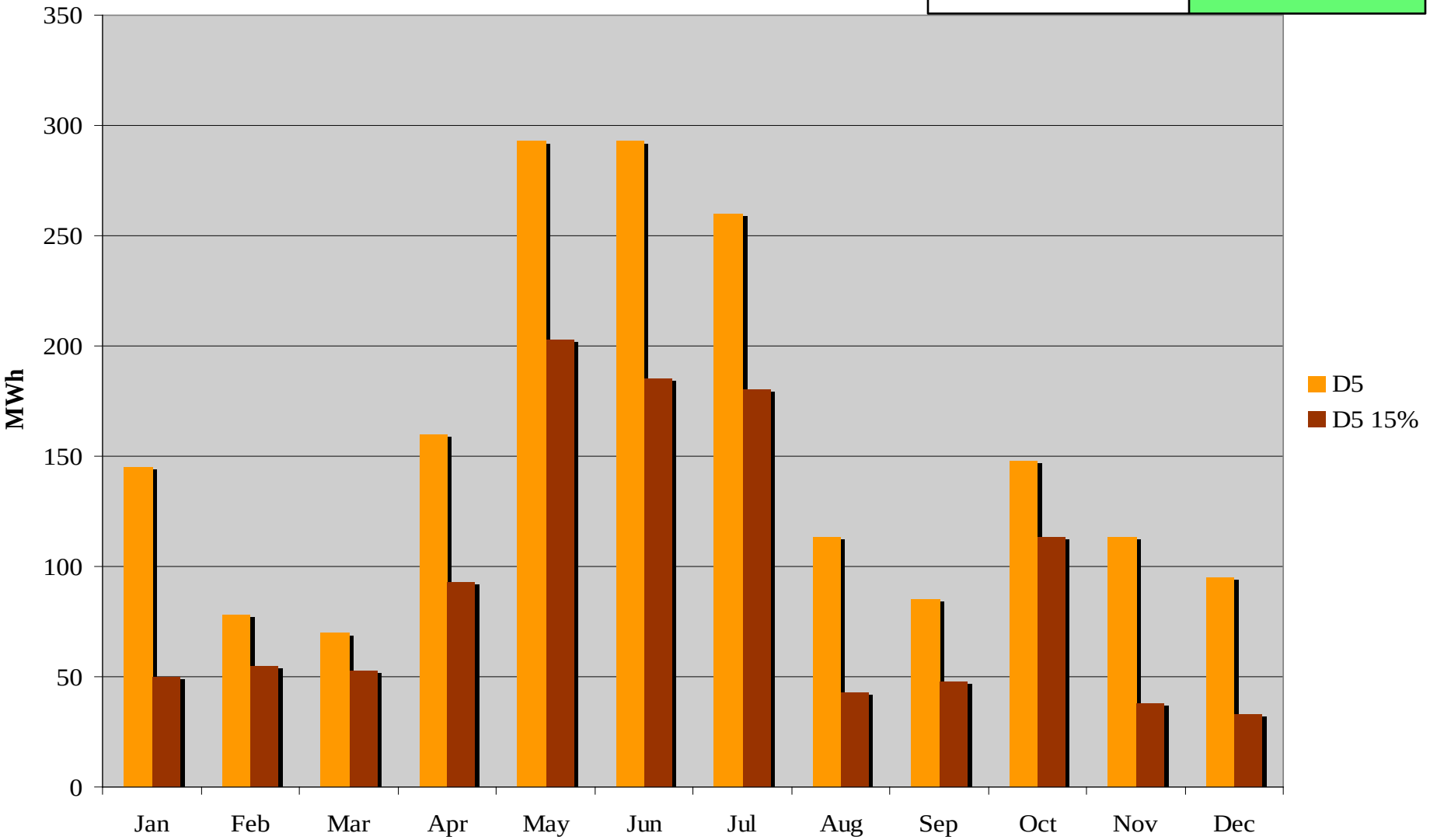
W/O Storage	1,853 MWh
W/ Storage	1,094 MWh
Net Decrease	759 MWh
% Decrease	41 %

D5 With and Without Storage



Storage Benefit for Peak Shaving

Generation from D1, D2 and D5 is significantly reduced

- **D1 reduced by 40%**
- **D2 reduced by 36%**
- **D5 reduced by 41%**

(Shown by results of Commodities run)

Storage Benefit for Stability

- **KIUC contracted EPS to conduct a stability study using PSSE software**

- **Study commenced in May 2006**
  - **–Final report recommends energy storage as an option to address stability issue**
  - **–Sandia Labs assisting EPS in storage requirements definition**