NATIONAL ENERGY TECHNOLOGY LABORATORY

Sensors and Controls - Techno-Economic Analysis for Existing Generating Units

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U.S. DEPARTMENT OF ENERGY

NETL – Program Planning and Analysis

Conduct analyses for multiple programs at NETL to assess:

- **Market potential**
- **Cost and performance**
- **Barriers to entry**
- **Benefits to Society**

Top 10% of Coal Fired Generating Fleet is Over 5pp More Efficient than the Average

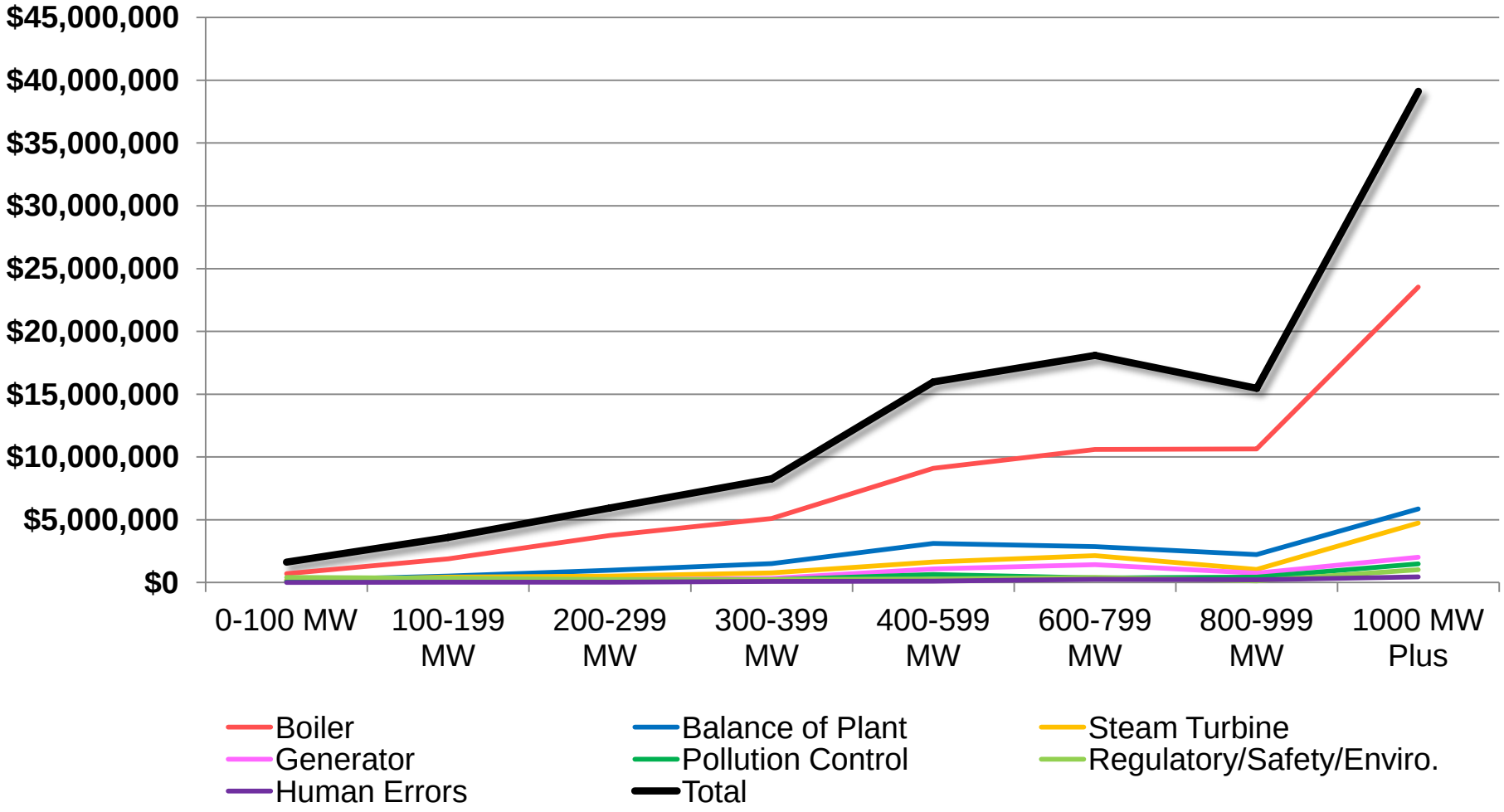
	2008 Top 10%		2008 Rest of Fleet	
	Average	Range	Average	Range
Generation Weighted Efficiency	**37.6%**	36.3% - 43.7%	32.0%	19.5% - 36.2%
Capacity (MW)	580	114 - 1426	329	27 - 1300
% of units that are Super Critical	55%	-	10%	-
Steam Pressure (psig)	2935	1800 - 3500	2088	600 - 5000
Age (yrs)	40	1 - 54	42	1 - 69
Load Factor*	83%	67% - 99%	75%	24% - 105%
% of units burning Bituminous Coal	66%	-	56%	-
% of units with SO2 Controls	36%	-	35%	-

Significant overlap in characteristics of the top 10% called into questions the General "rules of thumb" regarding efficiency

Source: *Improving the Efficiency of Coal-Fired Power Plants for Near Term Greenhouse Gas Emissions Reductions*
http://www.netl.doe.gov/energy-analyses/pubs/ImpCFPPGHGRdctns_0410.pdf

Availability

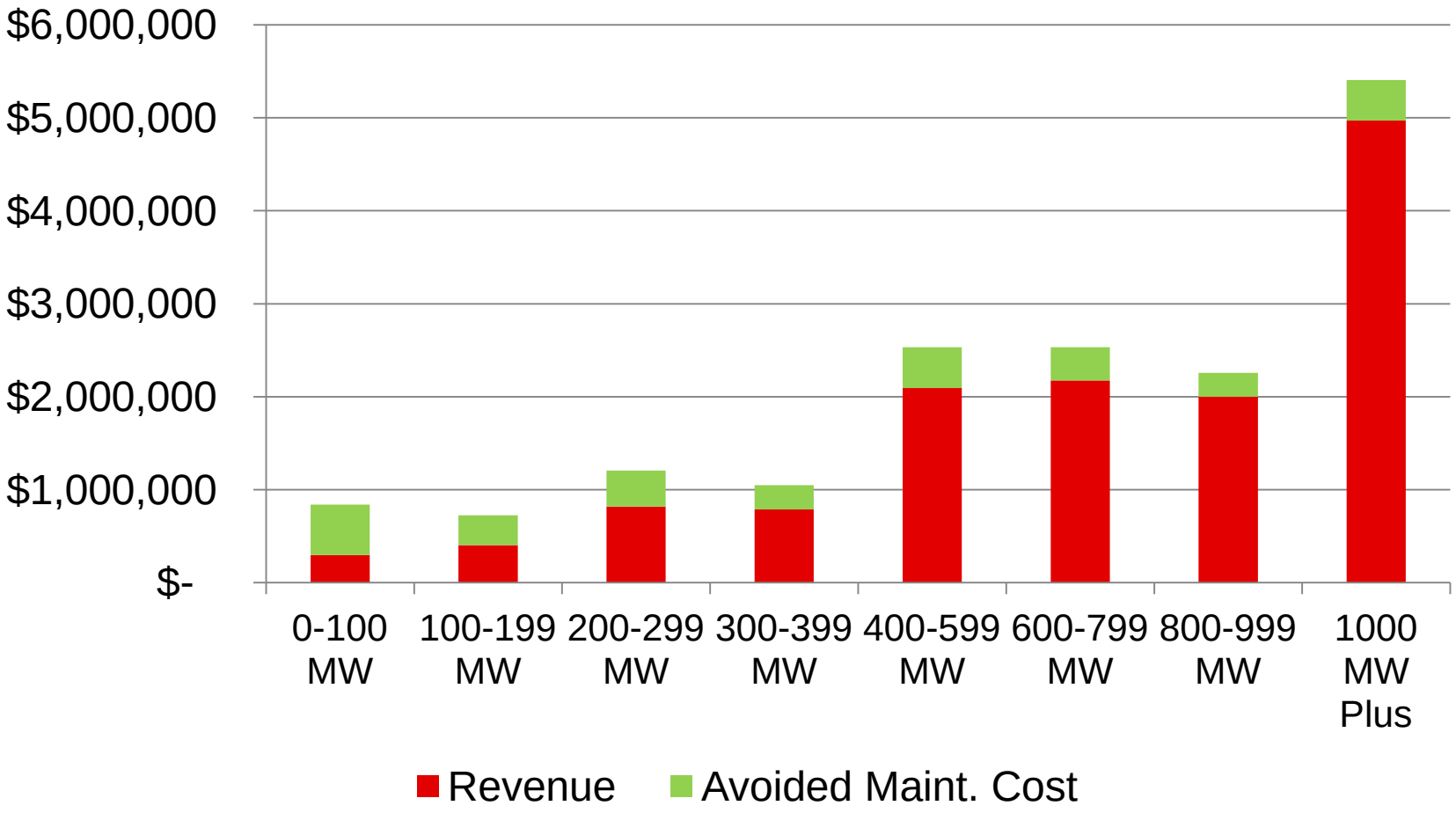
2005-2009 Average Annual Plant Revenue Loss Due to Equipment Forced Outages and Derates (2011 $)



Source: Outage Data - NERC GADS Database 7/28/10 Accessed 4/18/11; Avg. Wholesale Price Data – EIA
http://www.eia.doe.gov/cneaf/electricity/wholesale/wholesale.html Wholesale Market Data, PJM West, NEPOOL, ERCOT Wtg. Avg;

Availability

Potential Revenue Increase and Avoided Maintenance Costs per based on 10% Decrease in Forced and Unplanned Maintenance Outages



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Cost and Performance of Previous Sensors and Controls Projects

MWs	Capital Cost (Thousand $)	O&M Cost (Thousand $/yr)	Reduction in Operator Cost (Thousand $/yr/unit)	Reduction in HR (Btu/KWh)	Nox Reduction (%)	Availability Improvements		
						Increased Operation Hours (Hr/Yr)	Net Generation Increase (MWh)	Contract Maint. Savings (Thousand $/Yr)
0-99	$500 - $600	$50 - $60	$120	175 - 225	5 - 8	75	4,500	$450
100-199	$500 - $600	$50 - $60	$120	175 - 225	5 - 8	79	10, 700	$470
200-299	$600 - $700	$60 - $70	$120	125 - 175	5 - 8	77	17,500	$460
300-399	$600 - $700	$60 - $70	$120	125 - 175	5 - 8	78	25,500	$465
400-599	$800 - $900	$70 - $80	$120	75 - 125	5 - 8	100	52,000	$600
600-799	$800 - $900	$70 - $80	$120	75 - 125	5 - 8	85	56,500	$510
800-999	$900- $1,000	$80 - $90	$120	25 - 75	5 - 8	55	46,000	$325
1000+	$900 - $1,000	$80 - $90	$120	25 - 75	5 - 8	100	125, 000	$600

Source: Worley Parsons opinion after review of past projects involving sensors and controls. Draft Paper by Peter Kabatec, Impact of Existing Sensors and Controls on Coal-Fired Power Plant Performance

Business Case Tool - Net Present Value Analysis (NPV)

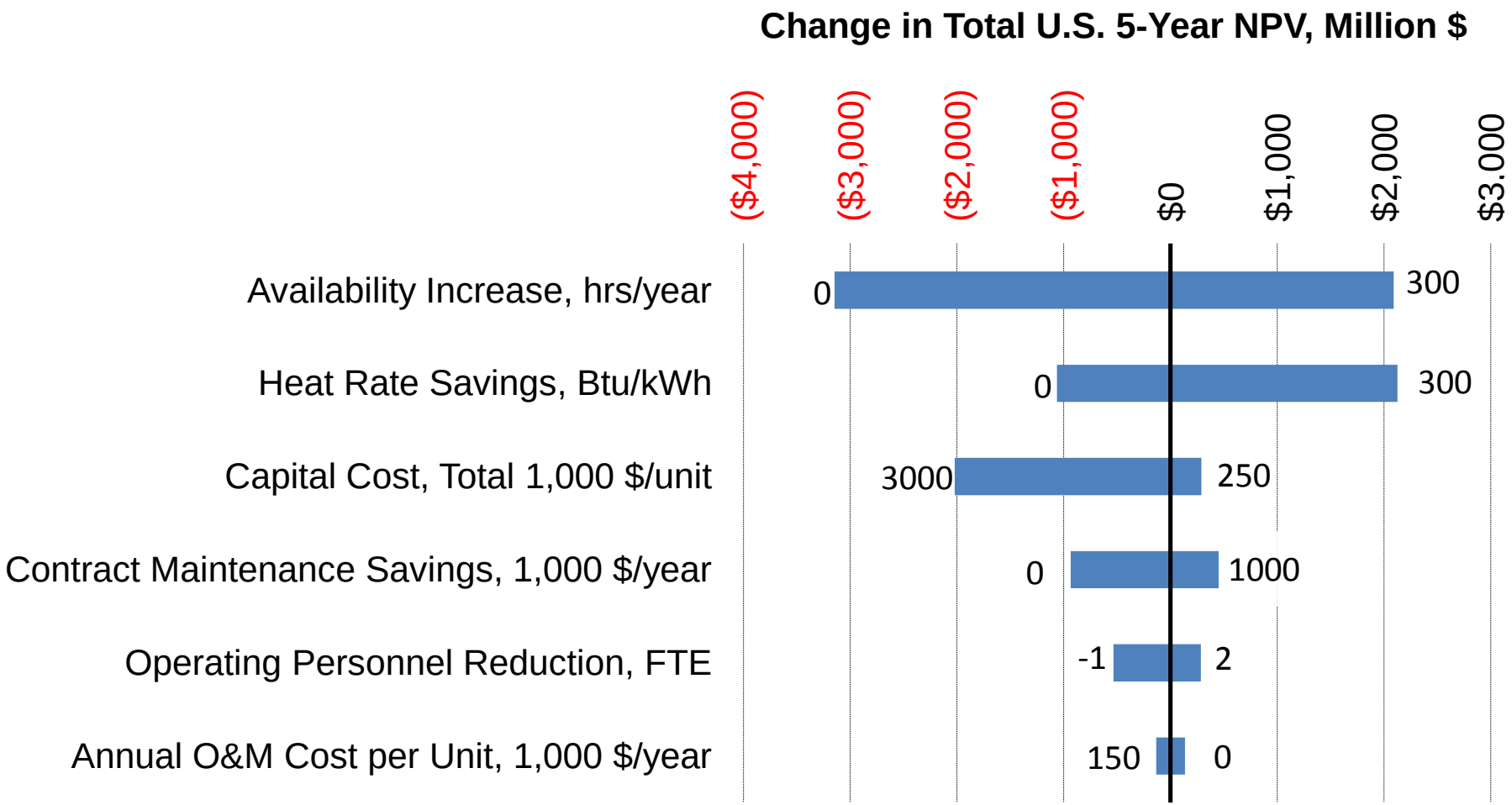
- Previous table established input ranges to determine which plants would benefit economically from a Sensors and Controls refurbishment project.

- Obtained Unit level data from the Energy Velocity database
  - Electric price
  - Fuel price
  - Current heat rate
  - Emissions
  - Capacity Factor

- Built an NPV tool to model the business case decision of each unit

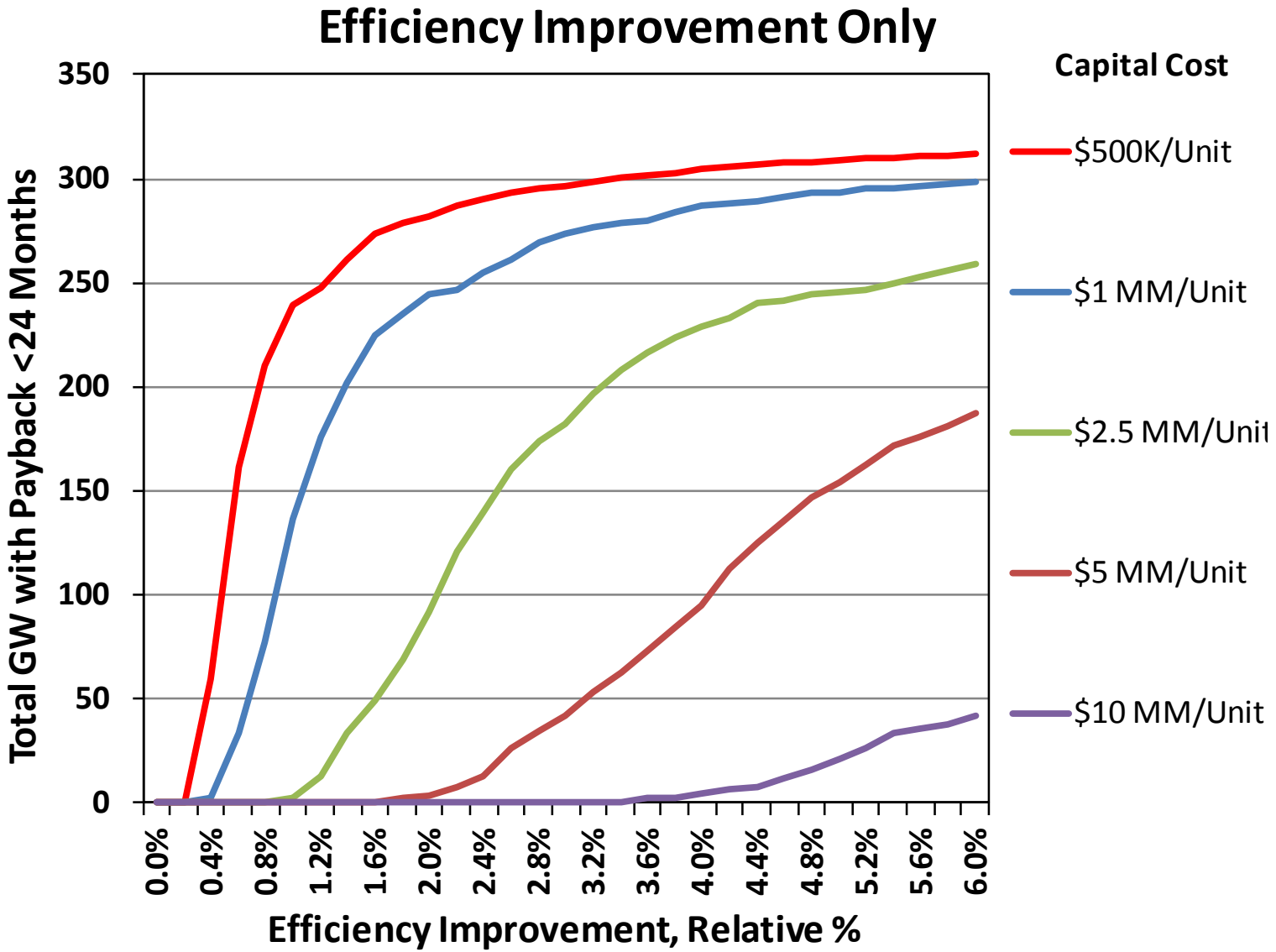
- Assumed units would only refurbish if they could payback in 2 years

Net Present Value Analysis - Sensitivities



Source: Results based on unit by unit discounted cash flow model. Unit level data taken from 2010 EV database. Cost and performance based on NETL survey of previous sensors and controls projects.

Net Present Value Analysis - Results



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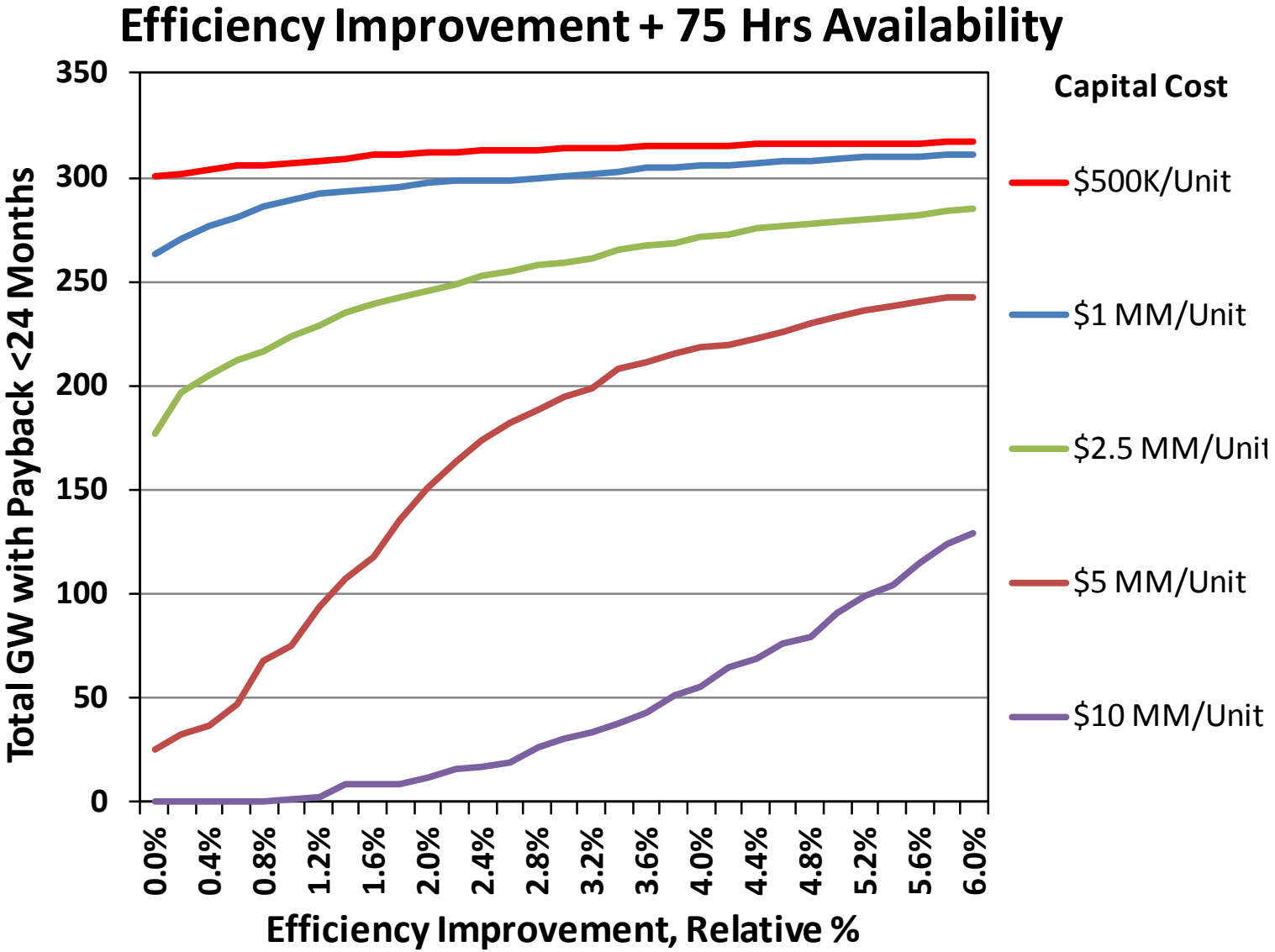


Source: Results based on unit by unit discounted cash flow model. Unit level data taken from 2010 Ventyx database. Cost and performance based on NETL survey of previous sensors and controls projects.

Conclusion

- **Advanced Sensors and Controls have the potential to be economically installed on 150GW to 300GW of the existing coal power generation fleet.**

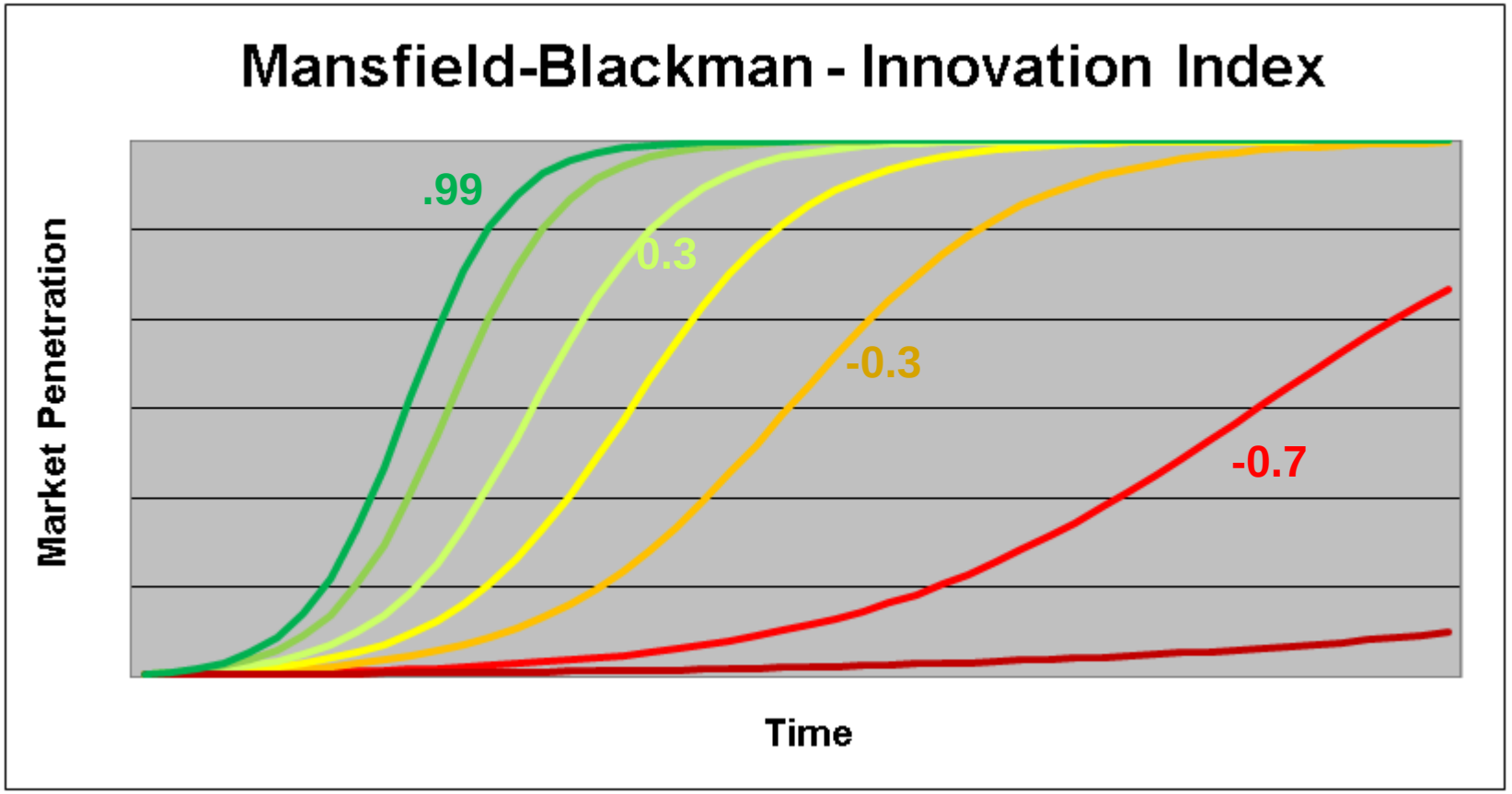
- **Availability is the key driver in determining the economics of refurbishment projects. Reducing forced outages by 10% alone would make it economical for most of the coal fleet to refurbish at capital costs under $1 million.**

- **Coal fired power plant CO_2 emissions could be reduced around 1% or 20 million metric tons per year from Advanced Sensors and Controls refurbishment. Cost $2-$10/mt CO_2 avoided.**

Future Work

- **Add NG-fired mid and baseload units**
- **Conduct similar analysis for advanced materials**

Homework Question



What do we need to move Fossil Energy's Innovation index form -0.7 to +0.7?

Backup

Individual Unit Best Year Efficiency

Decile	2008 Efficiency	1998 - 2008 Best Year Efficiency
1	27.6%	29.9%
2	29.9%	31.7%
3	30.8%	32.5%
4	31.6%	33.3%
5	32.2%	34.1%
6	32.9%	35.0%
7	33.8%	35.8%
8	34.7%	36.9%
9	35.7%	37.7%
10	37.6%	39.7%
Average	**32.5%**	**34.5%**

- **An individual unit had varied efficiency over the 10 year period in EV**
- **Setting each unit to the highest achieved efficiency (1998-2008), yields overall fleet efficiency that is 2pp higher than 2008.**
- **Best year efficiency did not occur in years with highest load factors and seemed unrelated to changes in coal type.**
- **In most cases increase was not due to major refurbishment. Increase may be due to better operation or maintenance cycle.**

Data Source: Ventyx's Energy Velocity 1998-2008 average net heat rate data for coal-fired units using 97% or more coal. Heat rates were weighted by capacity and units with missing or anomalous data were omitted. Omitted units accounted for 3% of generation

Summary of NEMS Run Results 2035

	Refurbish Capacity (GW)	Coal Generation (BkWh)	Average US COE (¢/kWh)	Total Electric Sales (BkWh)	US Total Electric Bill
AEO2011 Reference	0	2197	9.2	4474	412
No NSR	255	2225	9.1	4491	410
With NSR	133	2204	9.2	4477	411

- **Program benefits from reductions in cost of electricity** (assuming plant optimization program continues to be funded at current levels)
  - **IRR of 22% to 30%**
  - **ROI at 8% discount rate of 5:1 – 15:1.**

Sensors and Controls Expansion to Other Plant Types

Breakdown of Existing Generation Fleet

Fuel Type	# Units	Capacity (GW)	Percentage of Total Capacity	2010 Generation (BkWh)	Percentage of 2010 Generation
Coal	863	318.3	29%	1917	44%
NG - Mid and Baseload	789	269.1	24%	630	14%
NG Peaking	1823	205.2	19%	283	7%
Nuclear	103	110.5	10%	899	21%
Hydro - Mid and Baseload	49	2.7	0.2%	290	7%
Hydro - Peaking Units	849	60.9	6%		
Wind	491	51.9	5%	97	2%
Petroleum	385	37.6	3%	24	1%
Renewables excl. Hydro and Wind	303	16.3	1%	80	2%
Others	202	26.5	2%	129	3%

Source: Ventyx EV database, units over 25MW