Advanced Sensors and Controls - Market and Benefits Analysis

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Objective

- Outline the potential economic impact of improvements in unit availability and efficiency from the use of advanced sensors and controls in existing coal-fired and NGCC units

Sensors and Controls

Challenges and Solutions

- **Sensors and controls used in power systems must:**
  - Withstand extreme high temperatures and pressures
  - Operate in an environment with exposure to various corrosive slags and gases
  - Provide more and better data than previous generations

- **NETL's Crosscutting Research Program is funding research into advanced sensors and controls that have the potential to:**
  - Decrease the annual number of forced outage hours experienced by coal- and gas-fired power plants
  - Increase the efficiency of coal- and gas-fired power plants

NETL Crosscutting Research
Advanced Sensors and Controls Program

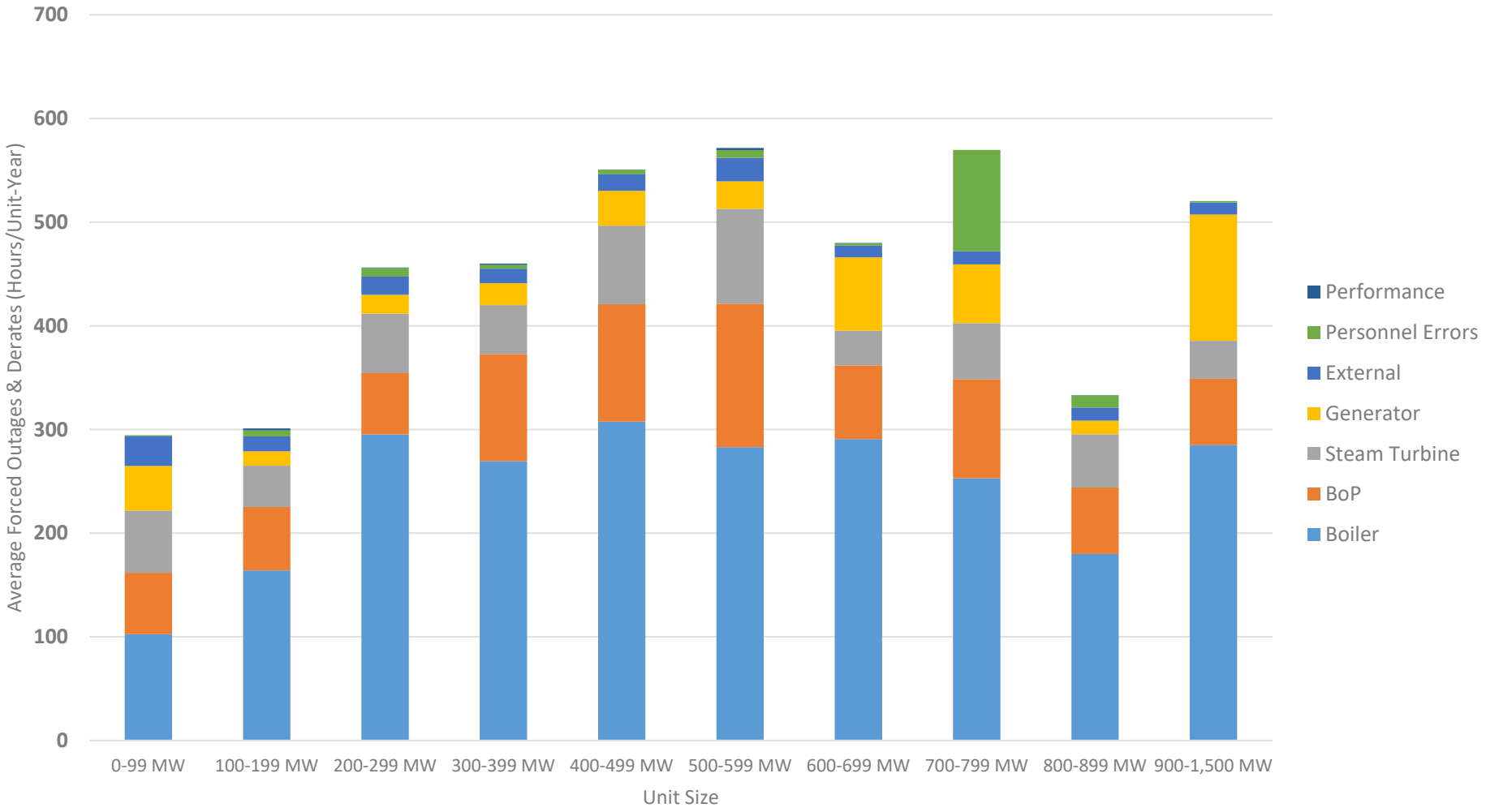
- **NETL research and development projects aim to develop the AS&C necessary to:**
  - Optimize both operation and performance
  - Achieve seamless, integrated, and intelligent power systems

- **Advanced sensors that are capable of operating within higher temperature and pressure conditions:**
  - Have the potential to improve operations within existing power plants
  - Are necessary for the even harsher environments that will exist within the next generation of advanced power systems

- **Advanced operational control systems are necessary for:**
  - Highly complex nature of advanced power systems that operate at high efficiency with low emissions

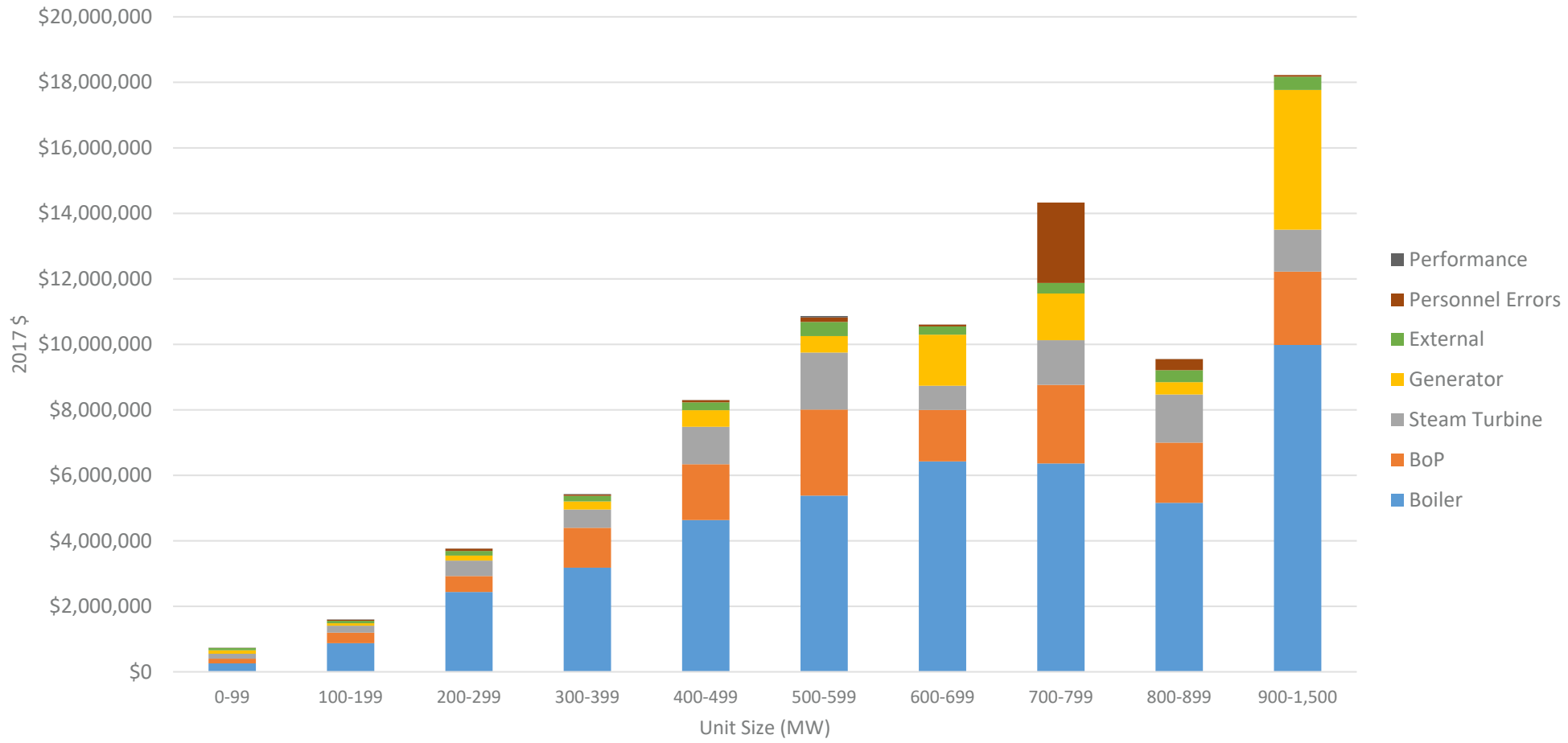
Generating Availability Data System (GADS)

Hours



Generating Availability Data System (GADS)

Cost



NERC Outage Categories

Type	Definition
Boiler	This set of codes contains the following: • Boiler • Boiler internals (tubes, refractory, supports, etc.) • All the fuel handling, storage fuel preparation, and burning equipment • The forced/induced draft air system • Slag and ash removal, except for particulate and gas cleanup (these latter items are covered under pollution control equipment) • The main steam and reheat steam systems up to but not including the turbine stop or isolation valves. • The feedwater system downstream of the final valve prior to entry into the economizer or boiler • Boiler blowdown systems. • The startup bypass system including drains up to the heaters or condenser • Boiler water chemistry problems not due to problems in the condensate/feedwater system, the chemical addition system, or the demineralizer/polisher system • The instruments and controls associated with the above equipment
Balance of Plant	This set of codes contains the following: • Condensing System • Condensate System • Feedwater System • Heater Drain Systems • Extraction Steam • Electrical • Auxiliary Systems
Steam Turbine	Besides the turbine, this set includes the steam stop/control valves, turbine control system, and the turbine auxiliaries (the extraction steam codes are contained in the Balance of Plant set): • High Pressure Turbine • Intermediate Pressure Turbine • Low Pressure Turbine • Valves • Piping • Lube Oil • Controls

Type	Definition
Generator	This set of codes contains the following: • Exciter • Cooling System • Controls
Pollution Control Equipment	This set of codes includes flue gas desulphurization equipment and stack gas particulate removal equipment: • Wet Scrubbers • Dry Scrubbers • Continuous Emissions Monitoring Systems • NOx Reduction Systems
External	This set of codes is used for events caused by external factors (flood, lightning, etc.), economic factors (lack of fuel, labor strikes, etc.), operator training, and transmission system problems
Regulatory, Safety, and Environmental	These codes apply only to events not directly attributable to equipment failures. Inspections or testing of certain equipment due to regulation are reported using the appropriate equipment cause codes, and the fact that it was a regulatory requirement noted in the verbal description section
Safety	This set of codes is for Occupational Safety and Health Administration -related retrofit or inspection, or other safety problem
Personnel Error	These codes apply to operator, maintenance, and contractor errors
Performance	This applies to total unit performance testing

Coal Unit-Level Analysis

- **Developed a spreadsheet-based cash flow model that performs unit-level economic analyses from the perspective of the owner**
  - Calculates the NPV of cash flows that occur after the installation of the new AS&C and the payback period
  - AS&C refurbishments occur in 2020
  - Full debt financing, 2-year repayment term

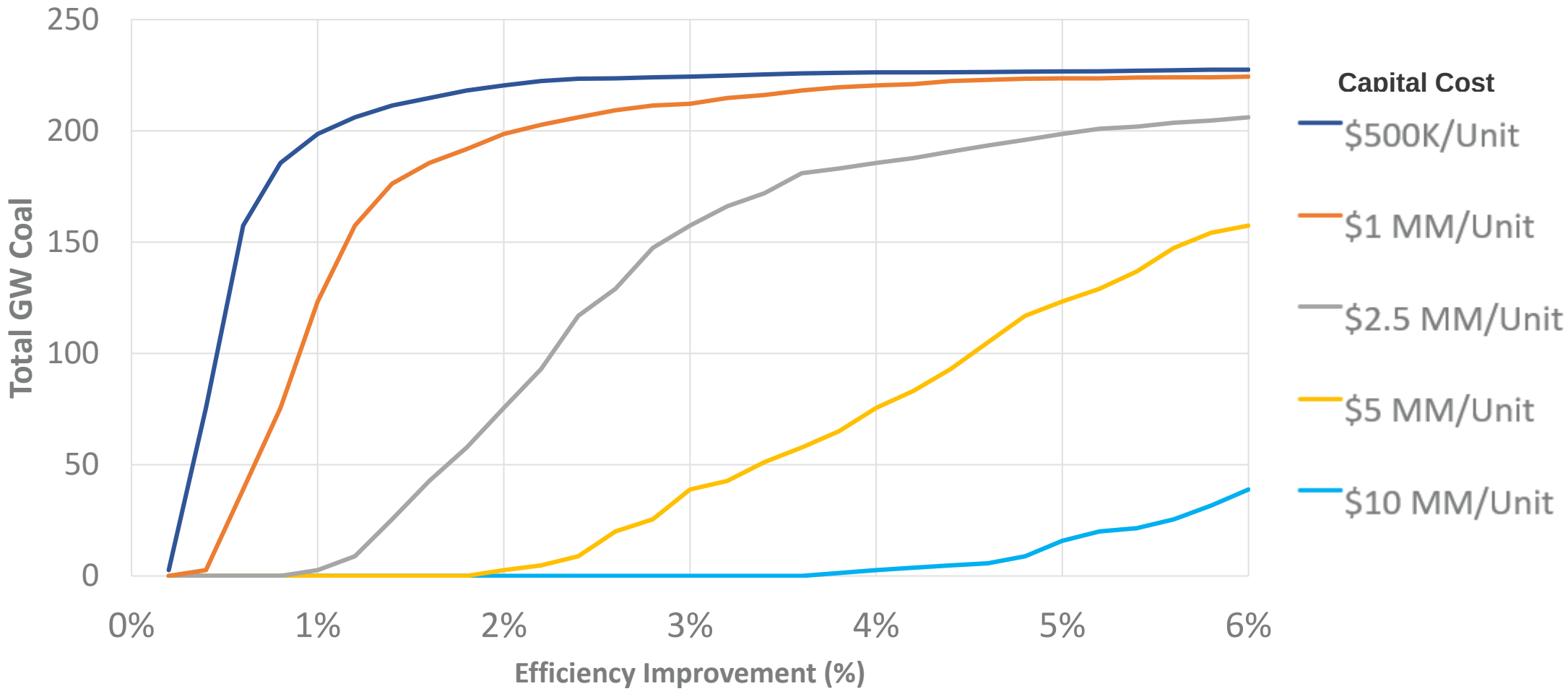
- **228 GW total capacity (458 units) are represented in the coal NPV analysis**
  - Exclusions include:
    - Coal-fired units scheduled to retire before 2025
    - Coal-fired units smaller than 50 MW capacity

Coal Sensors and Controls Input Data

Unit Capacity (MW)	Capital Cost ($1,000s)	Fixed/ Variable O&M Cost ($1,000s/ year)	Reduction in Operating Cost ($1,000s/ year/unit)	Heat Rate Reduction (Btu/kWh)	Sensors & Controls Availability Improvements		
					Increased Operation Hours (Hours/Year)	Net Generation Increase (MWh)	Contract Maintenance Savings ($1,000s/ Year)
0–99	$500–$600	$50–$60	$120	175–225	91	5,392	$540
100–199	$500–$600	$50–$60	$120	175–225	54	7,317	$320
200–299	$600–$700	$60–$70	$120	125–175	65	14,885	$390
300–399	$600–$700	$60–$70	$120	125–175	44	14,290	$260
400–599	$800–$900	$70–$80	$120	75–125	74	38,000	$440
600–799	$800–$900	$70–$80	$120	75–125	60	39.515	$360
800–999	$900–$1000	$80–$90	$120	25–75	43	36,328	$255
1000+	$900–$1000	$80–$90	$120	25–75	73	90,263	$435

NPV Model Results for Coal-Fired Units

2 year payback period

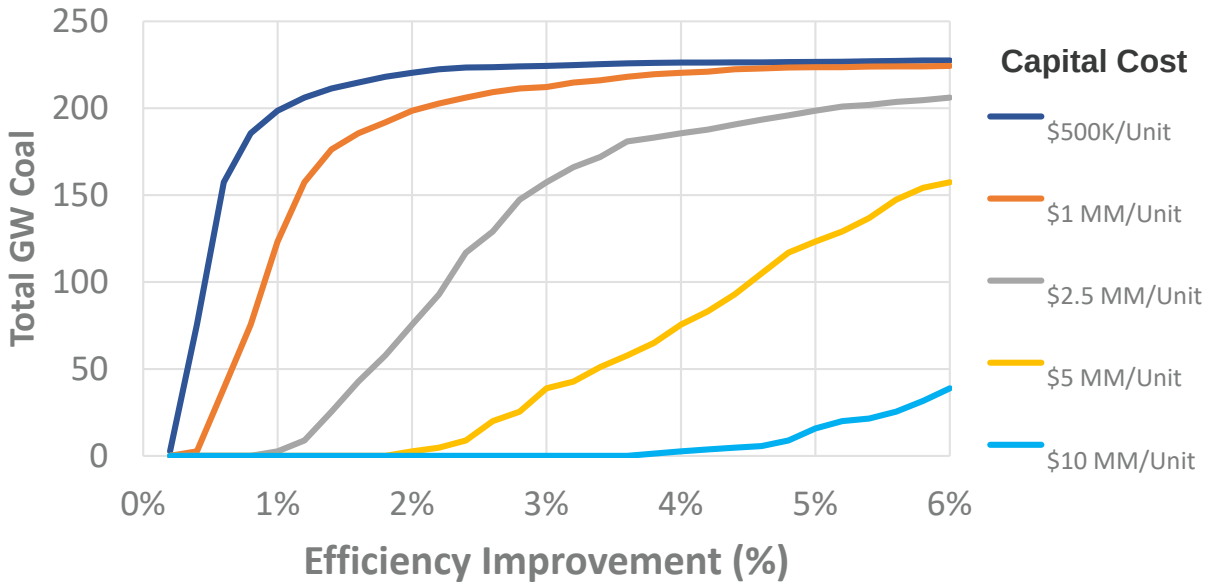


NPV Model Results for Coal-Fired Units

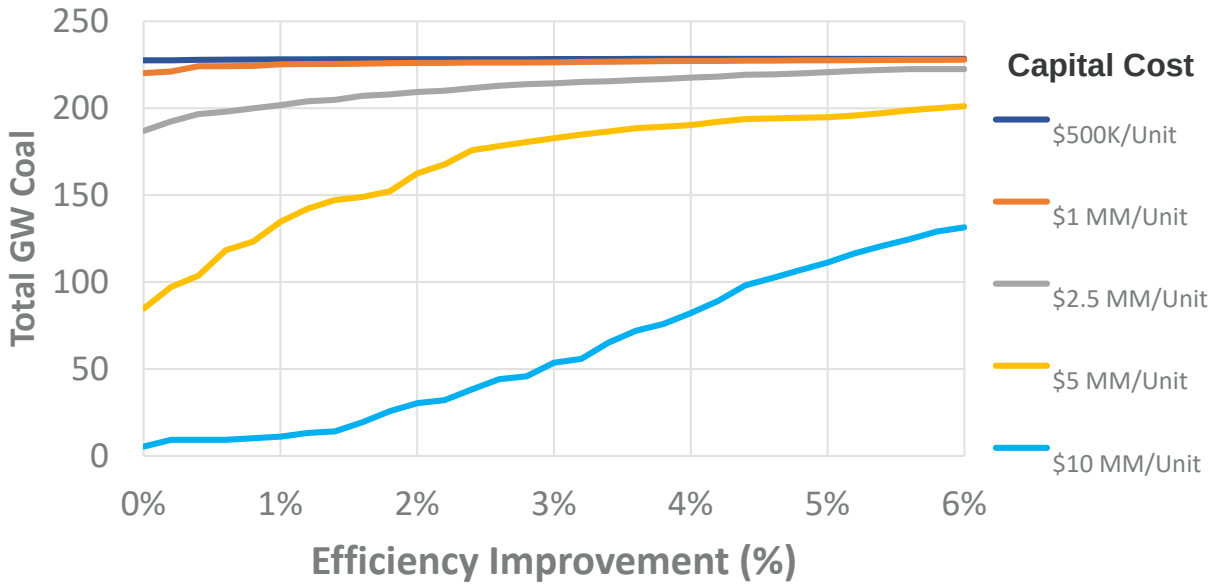
2 year payback period

Capacity Factor, CF_0	Hours/year @CF_0	Increase CF_1 with 75 hours
85%	7,446	85.9%
65%	5,694	65.9%
55%	4,818	55.9%

Efficiency Improvement Only



Efficiency Improvement + 75 Hrs



75 hrs = 3 days and 3 hours

Conclusions

- According to the North American Electric Reliability Corporation's (NERC) Generating Availability Data System (GADS) database, the average annual forced outage hours in coal-fired units range from roughly 300 to nearly 600 hours per unit across the different generator unit sizes. These annual forced outage hours represent 300,000 to 600,000 MWh in lost production, and associated annual revenue losses from $1 million to just over $18 million (in 2017 $) across the unit size ranges.
- Availability is more important than efficiency
- The Crosscutting Research Program at NETL is currently funding research into AS&C technologies that are capable of withstanding higher-temperature and higher-pressure conditions and have the potential to decrease the annual number of forced outage hours experienced and increase the efficiency of existing coal-fired and NGCC power plants.
- This analysis has shown that AS&C have the potential to be economically installed on 228 GW of the existing coal-fired power generation fleet and on roughly 100 GW of the existing NGCC fleet. The resulting decrease in electricity end-use prices and electricity expenditure savings suggest an IRR of 53–70 percent (assuming current program funding levels through 2020).

IEA's Clean Coal Centre Webinar

Power Plant Design and Management for Unit Cycling and Load Fluctuation"
Remarks on Instrumentation and Controls (I&C)

- Vital for all power plant operational regimes
- I&C upgrade improves accuracy, reliability, and speed of control
- Optimization of instrumentation and controls is the most cost-effective way and should be a precondition for other measures