Long-Term Carbon Injection Field Test for 90% Mercury Removal in a PRB Unit with an SCR, Spray Dryer and Fabric Filter

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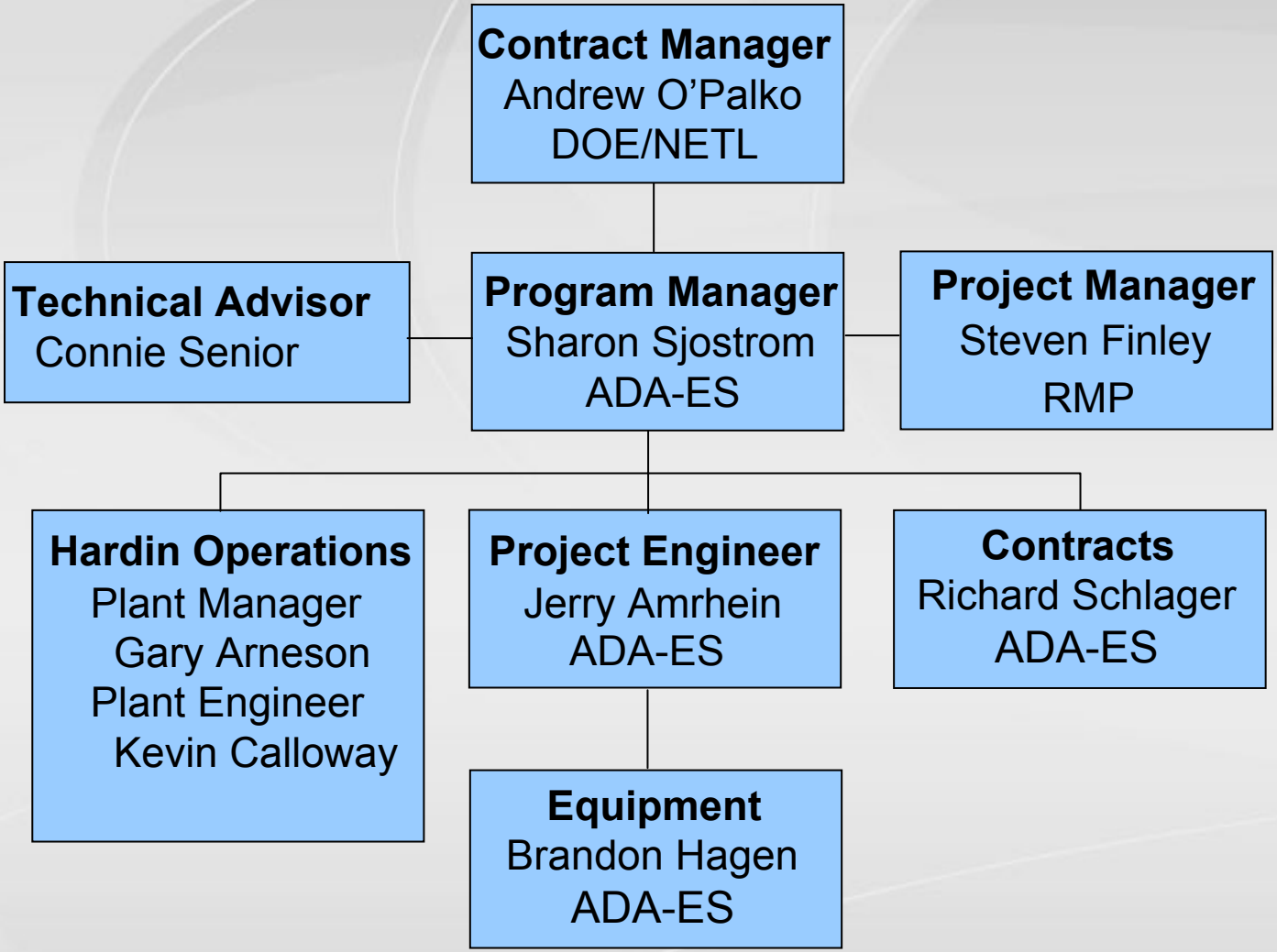
Hardin Project Organization



Project Co-Funders

- Rocky Mountain Power
- Norit Americas
- Calgon Carbon
- Thermo Fisher
- Teledyne Monitor Labs
- Arch Coal
- Roundup Trading International
- Westmoreland Coal Sales
- Air Sampling Associates

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Project Goals

- Maintain 90% mercury removal
- Install commercial equipment to meet anticipated regulations
  - Install a sorbent injection system and integrate into plant controls
  - Install a commercial Hg CEM and integrate into plant DAHS
  - Develop and implement feedback control system
- Determine representative operating costs
  - Train plant operators
  - Operate equipment according to pending and anticipated regulations

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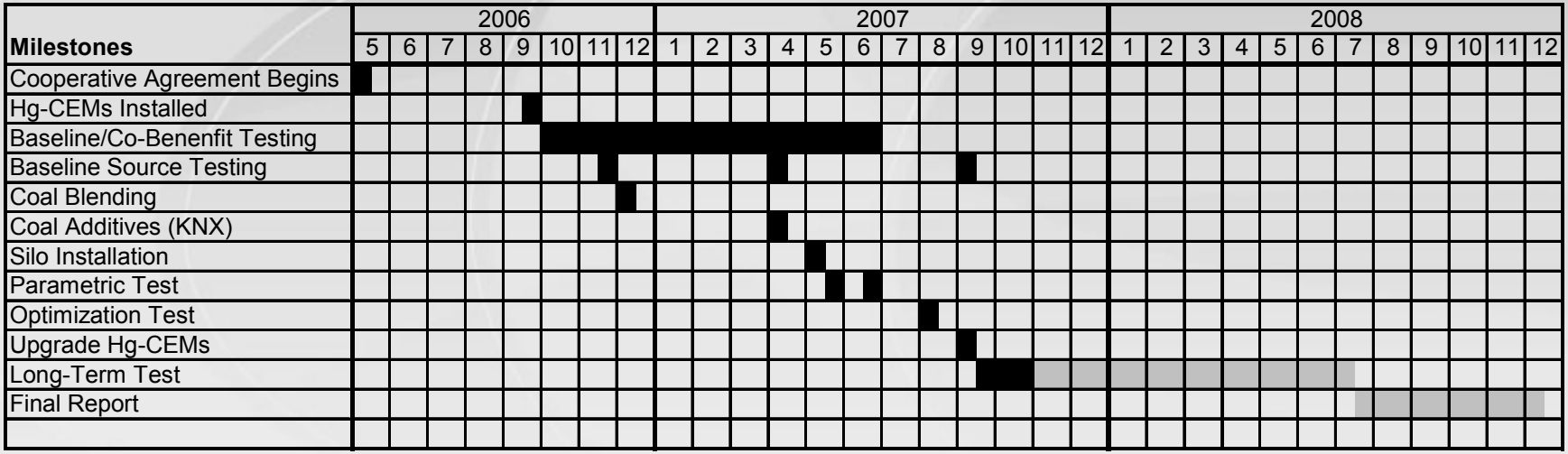
Secondary Project Goals

- Evaluate any **co-benefits** (e.g. effect of the SCR).
- Evaluate **coal additives** to enhance mercury removal.
- Evaluate **coal blending** with Western bituminous coal.
- Evaluate the cost reduction potential from using feedback control from the Hg-CEMs.
- Evaluate impact of enhanced carbons on ash disposal.
- Provide data and support to RMP and M-DEQ to for a BACT analysis of technology implementation.

Milestone Timeline



Hardin Station

121 MW
Coal: PRB
(Absaloka Mine)
0.65% sulfur
<20 ppm chlorine
~ 0.04 μg/g Hg (dry)
LNB and SCR
SDA
FF


SDA
SCR
SDA Inlet
Injection and
Sample Ports
Air Heater
Gas Flow

Fabric Filter

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Project Tasks

Pre-Test Planning

1. Design and Installation
2. Field testing
   - Baseline testing
   - Co-Benefits Analysis
   - Parametric testing
   - Choose Long-Term Test Parameters
   - Long-term testing
4. Coal, Ash, and By-Product Sample Evaluation
5. Technology Transfer
6. Management and Reporting

Task 1: Design and Install Equipment

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Mercury Monitoring

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CEM QA/QC Protocol

- Daily zero/span check more strict than CAMR
  - CAMR "Critical" at
    Calibration Error > 5% (CE = |R-A|/S)
    or |R-A| = ± 1 µg/m^3 for < 5 µg/m^3
  - ADA-ES QA:
    2.5 % (± 0.5 µg/m^3) = high maintenance
    1% (± 0.2 µg/m^3) = low maintenance
- Weekly Converter Check (system integrity)
  - Oxidized mercury calibrator installed 11/5/07
- Quarterly linearity check
- Annual RATA test
  - More frequent abbreviated relative accuracy tests will be conducted for the DOE project

Method 30A or 30B recommended for RATA tests
90% control = ~ 0.4 µg/m^3 at Hardin outlet

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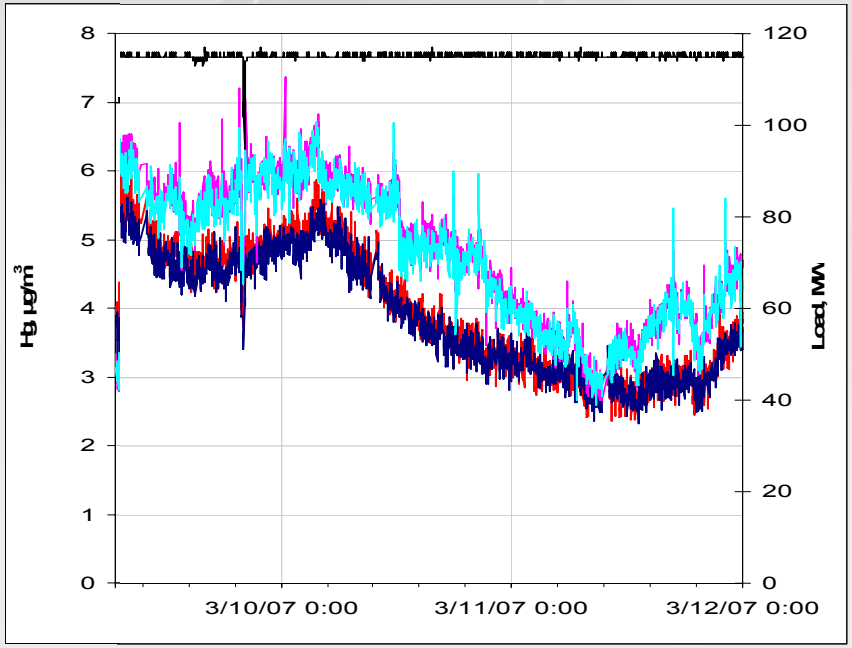
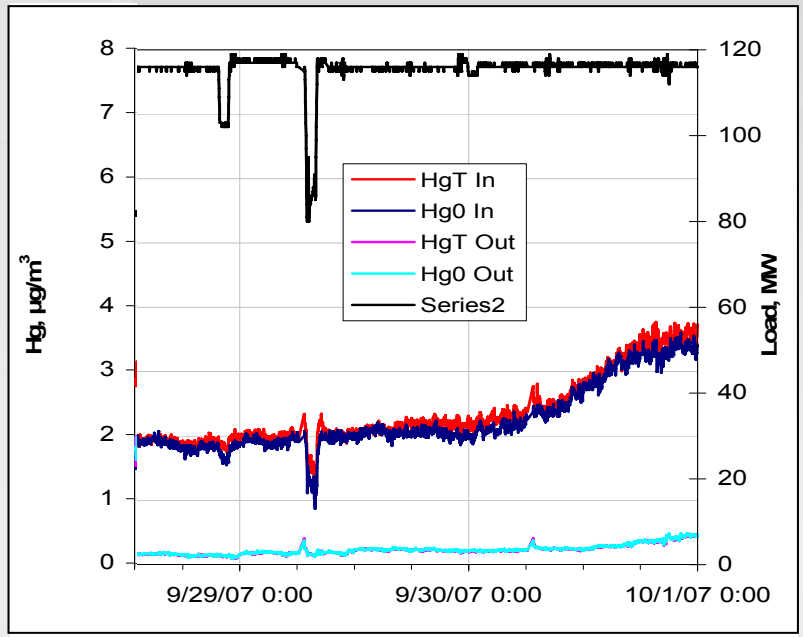
Commercial CEM: Effect of CEM Upgrades

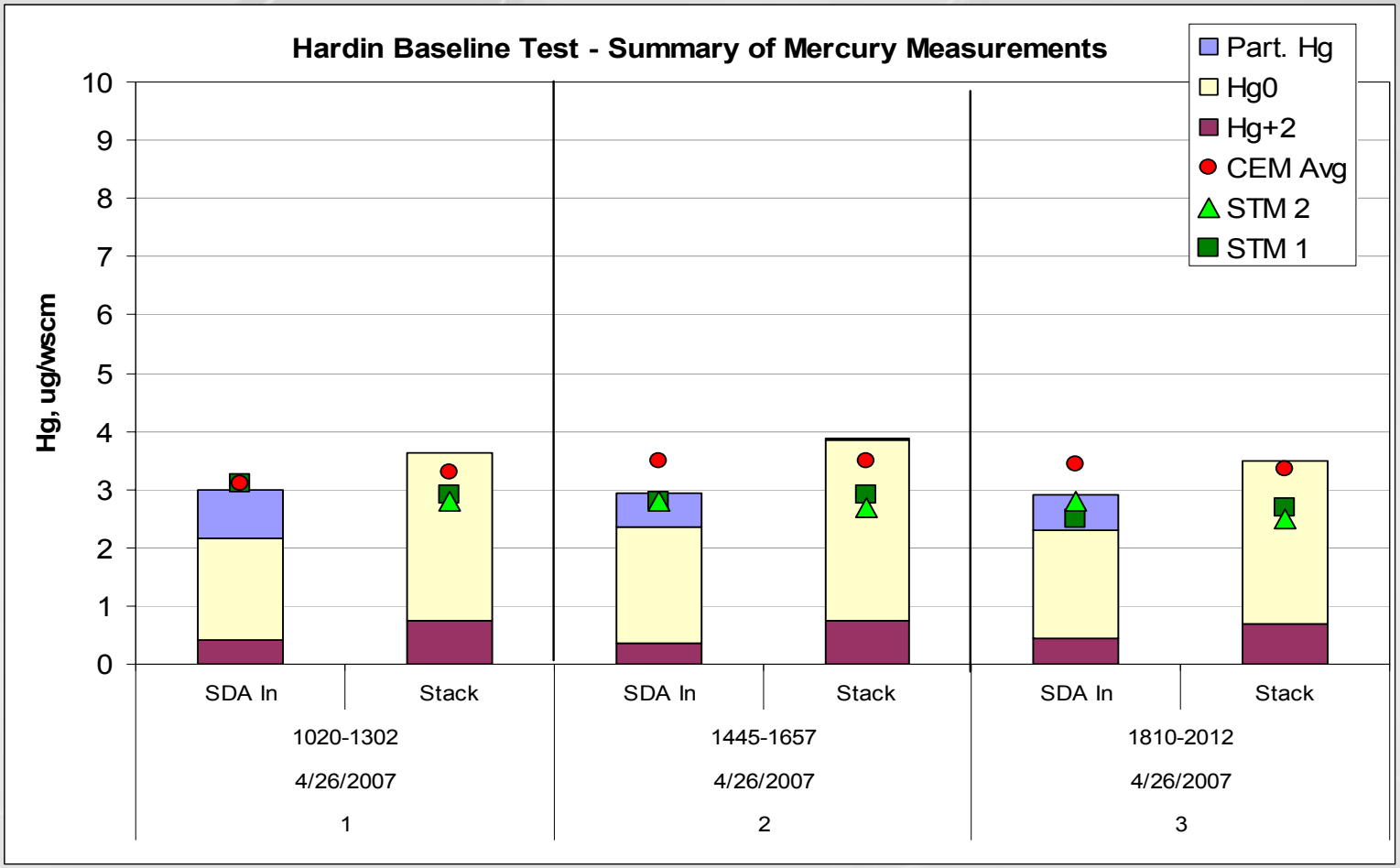


Before



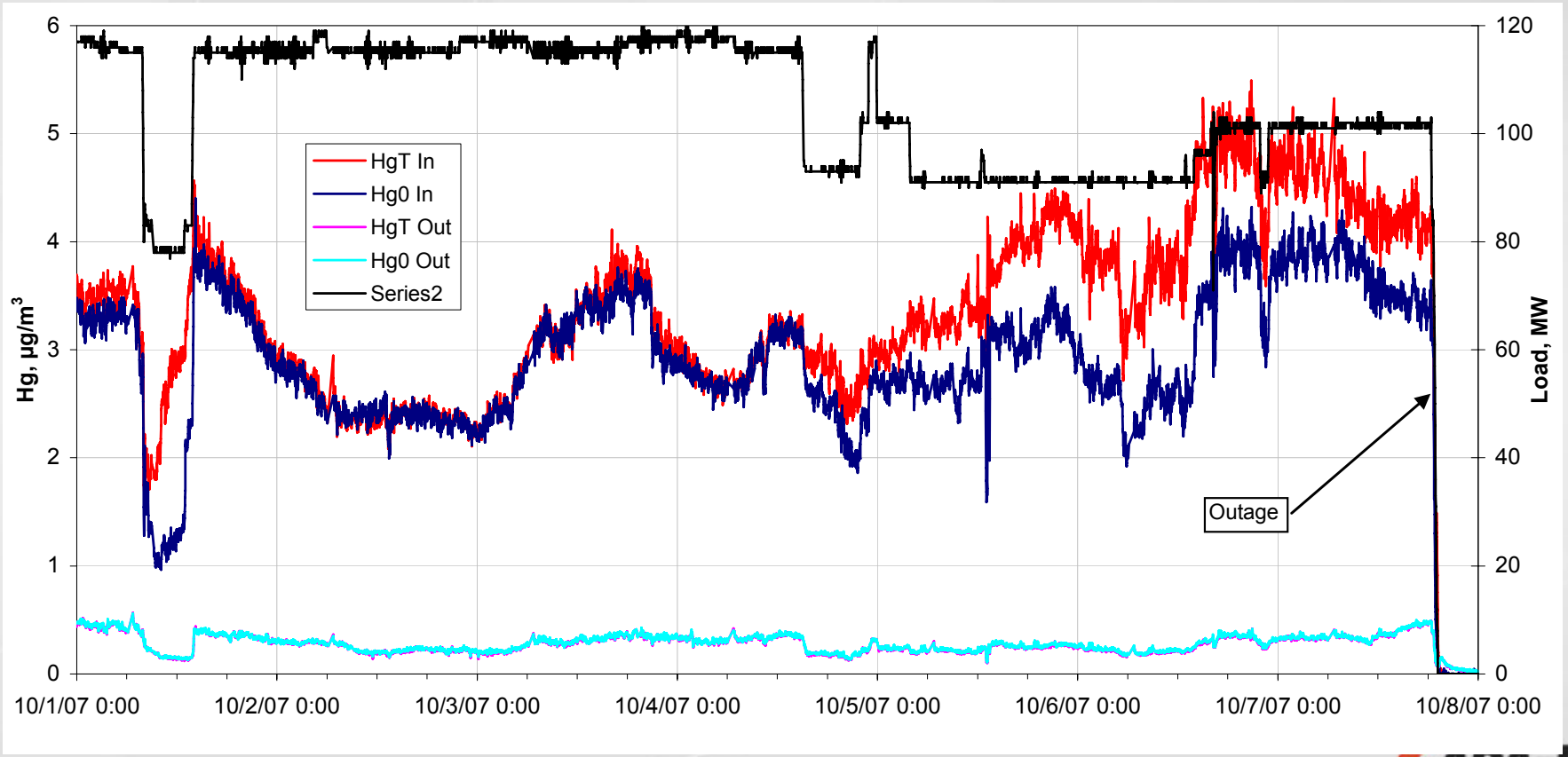
After

Baseline Mercury Removal



Co-Benefit: Effect of Boiler Load

- Low native mercury removal at full load
- Native mercury removal can be as high as 50% at reduced load
- PAC more effective at reduced load



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Coal Blending: December 2006

- Tested two Western Bit coals at two ratios, 7 & 14%
- It was difficult evaluate performance because coal mercury content changed during testing.

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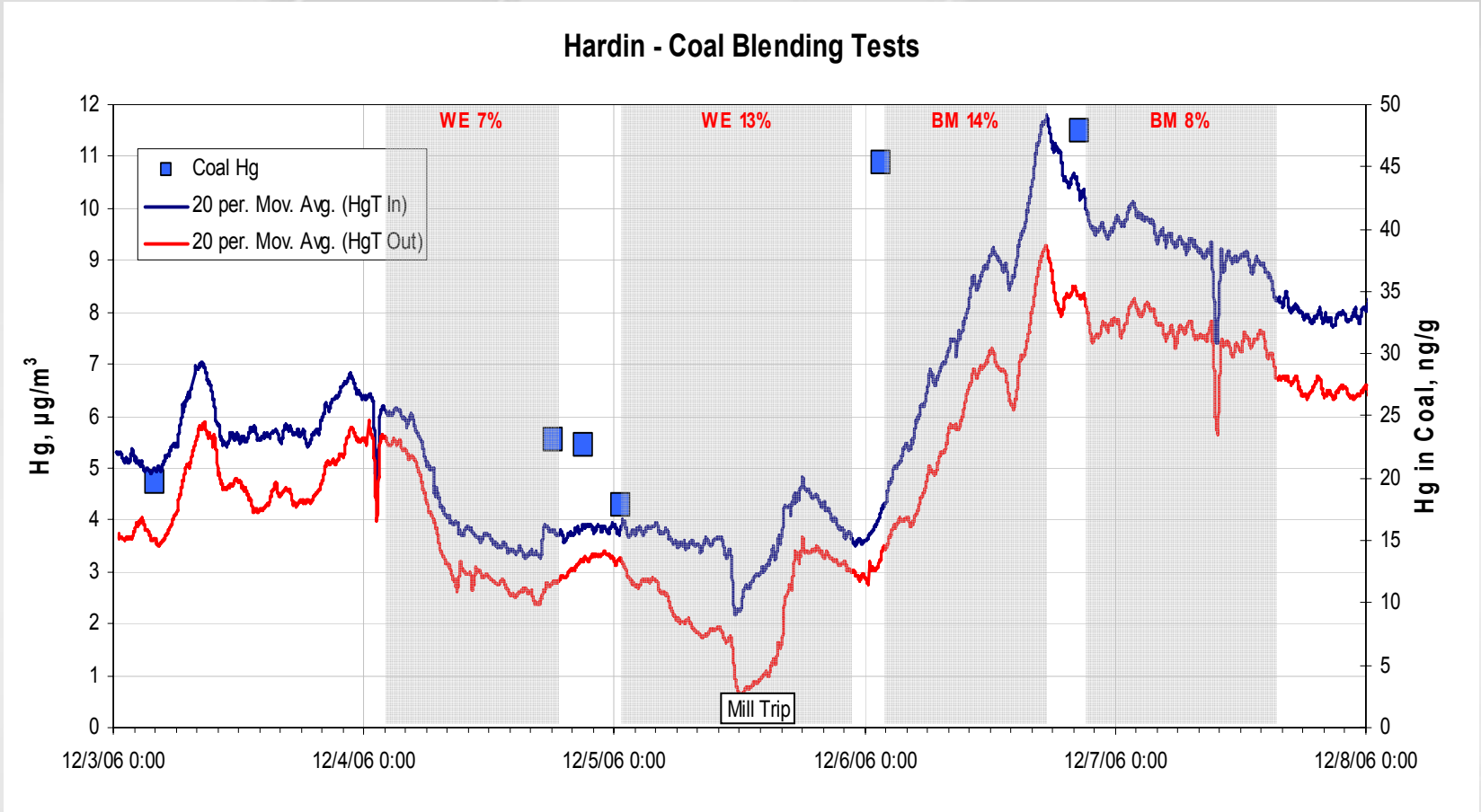
Coal Blending: December 2006



Coal Additives: April 2007

- Tested KNX at several different flow ratios

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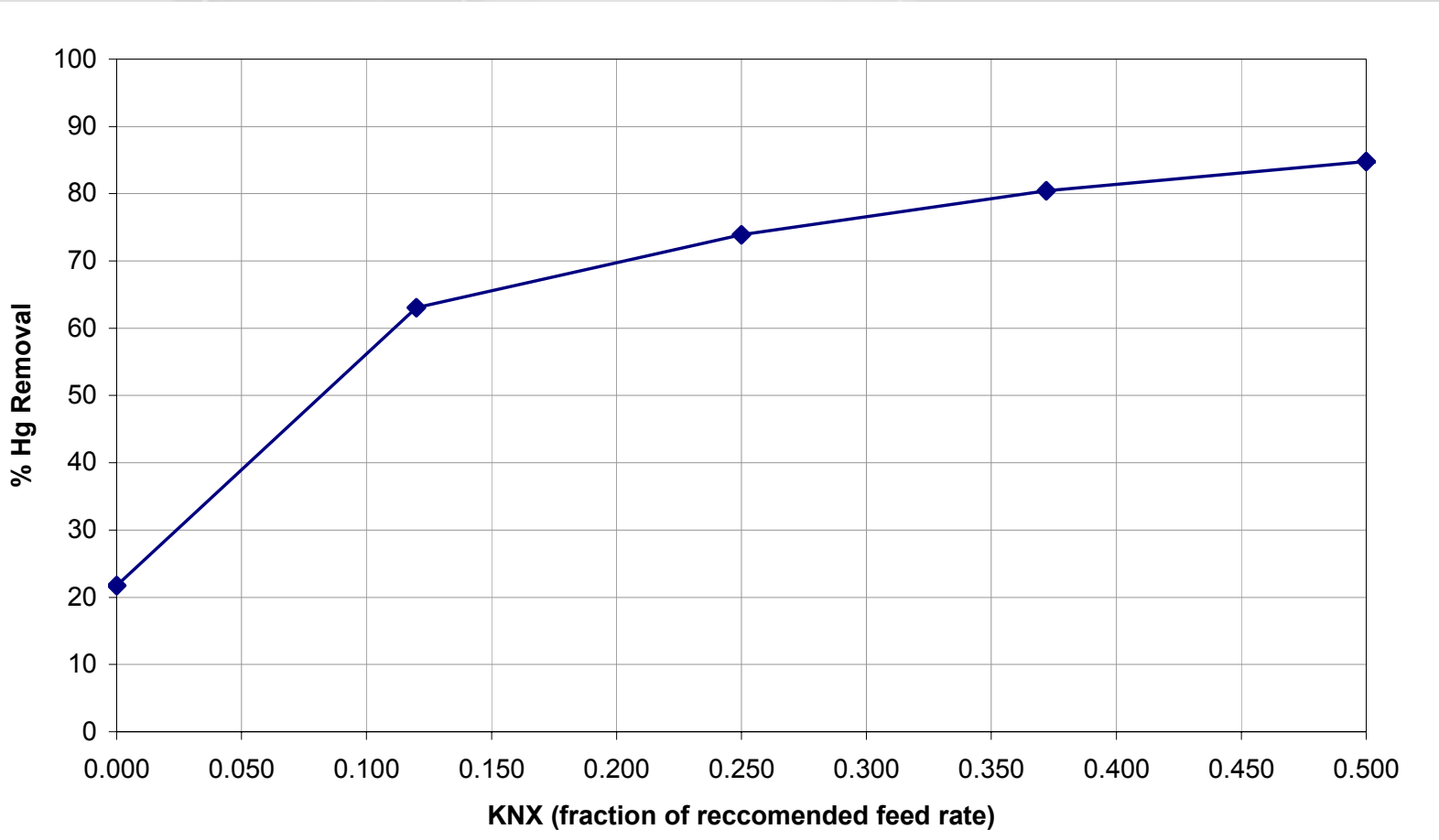
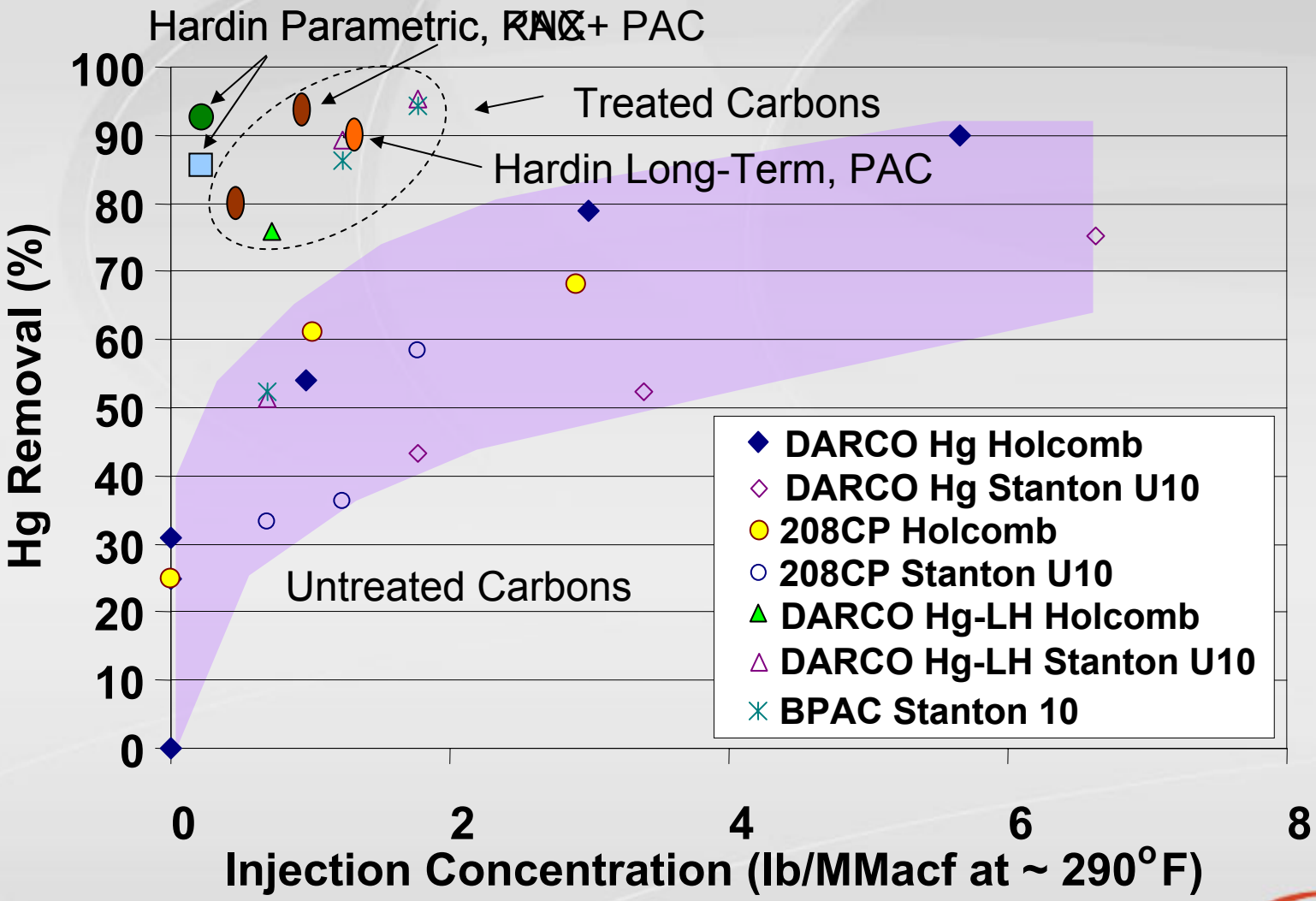
Coal Additives: April 2007

KNX Results



PAC Injection Results
SDA+ FF, PRB and ND Lignite Fuels



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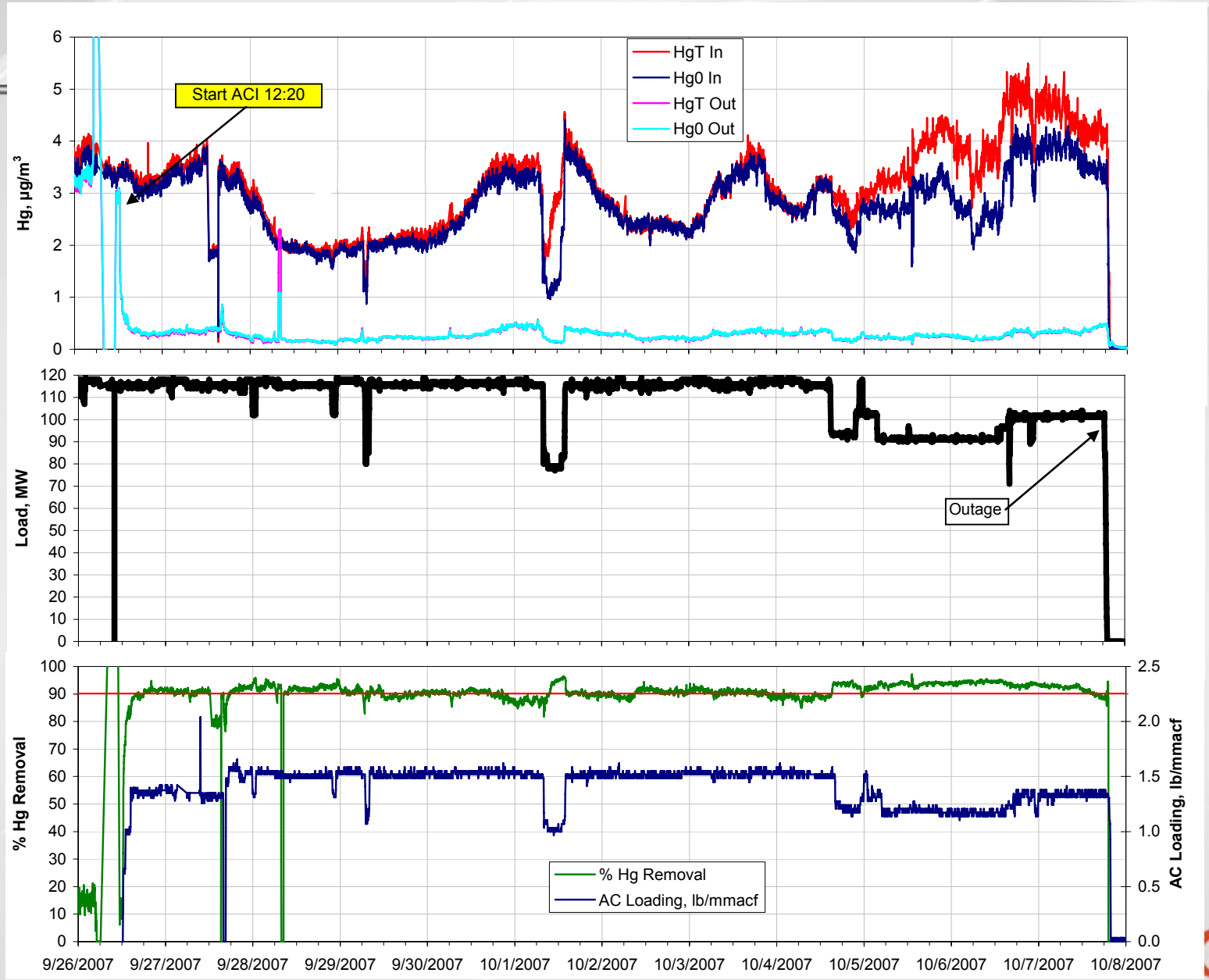
Long-Term Test: Sept ’07 – Sept ‘08



Preliminary Economics for Hardin

Mercury Removal Rate	90%*
Brominated PAC Injection rate for above removal	1.5 lb/MMacf (43.5 lbs/hr)
Native Mercury Removal	10 to 15%
Stack Flow	0.55 Macfm
Average Coal Mercury Concentration	2.7 lb/ TBtu
Mercury Removed	48.7 lb/ yr
Cost of PAC per pound of Mercury Removed	$4.6K **
20 Year Levelized Cost	$ 534,000 **
20 Year Levelized $/lb Mercury removed	$10,950 **

Capital Cost Estimate:$7.25/kW
O&M Cost Estimate: 0.43 mills/kW-hr***
Mercury Removal: $10,950/lb Hg Removed

* Includes baseline removal

** Loss of ash sales and disposal fees due to PAC are not applicable for ash + SDA product

*** Includes sorbent. Other O&M estimated. Cost data currently being collected.

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Summary

- Native Mercury Removal
  - Very low (typically << 20%) at full load
  - As high as 50% at reduced load
- Coal Additives
  - Up to 85% mercury removal with KNX™ during short-term parametric tests
- Coal Blending
  - Bull Mountain: only marginal increases in mercury removal
  - West Elk: 14% blend resulted in up to 51% mercury removal
- PAC Injection
  - Both FLUEPAC™MC PLUS and DARCO® Hg-LH and can achieve 90% mercury removal at 1 to 2 lb/MMacf
- Injection controls recently upgraded to allow feedback from CEMS
- Plant staff has been trained to operate CEMS and injection system
- O&M cost information currently being collected to improve cost estimate

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Questions?