DESTINATION 2050

Use of Nanocoating Leads to Full-Scale Power Plant Efficiency Gains

Pittsburgh Chemical Solutions

THERMOPHASE

FEBRUARY 11-13, 2025
DALLAS, TEXAS, USA

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What is THERMOPHASE?

THERMOPHASE

THERMOPHASE is a chemistry that provides a nanocoating on surfaces. It provides the following:

- Prevention of Fouling
- Improved Heat Transfer

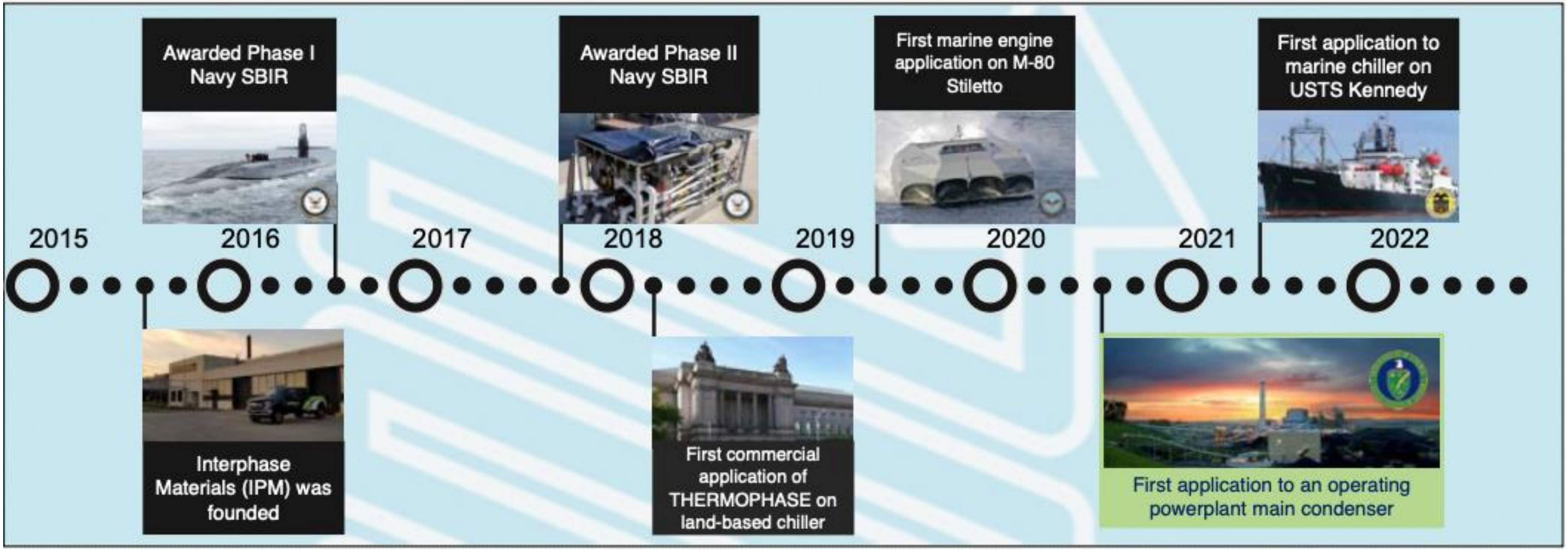
Benefits include:

- Improved efficiency (energy savings, fuel savings, etc.)
- Reduction of required maintenance
- Improved operation capability
- Reduction of emissions
- Reduced water usage
- Non-Hazardous/Non-biocide/Non-toxic

Product has been used in various industries (condensers, chillers, various types of heat exchangers, cooling towers, etc) including:

- Power Plants
- Hospitals
- Universities
- Industrial Facilities
- Marine Engines

THERMOPHASE Development History



- THERMOPHASE has been in development since Interphase Materials was founded in 2015 and has been funded from a variety of sources including the U.S. Navy Small Business Innovation Program (SBIR), the Rapid Reaction Technology Office (within the Department of Defense), the U.S. Department of Transportation Maritime Administration (MARAD) and the Department of Energy. THERMOPHASE has been available commercially for building cooling systems since 2018.

THERMOPHASE Mechanism of Action

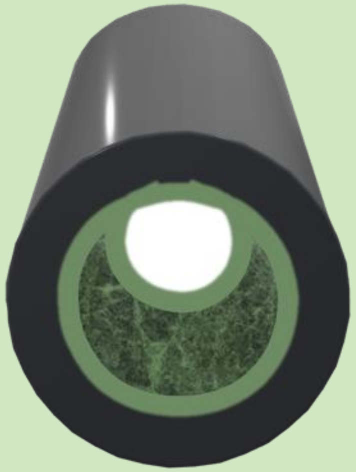
Condenser tube heat transfer is proportionate to:

Material Resistance R_M

Fouling Resistance R_F

Boundary Layer Resistance R_B

Tube Fouling over time increases the Fouling Resistance (R_F)



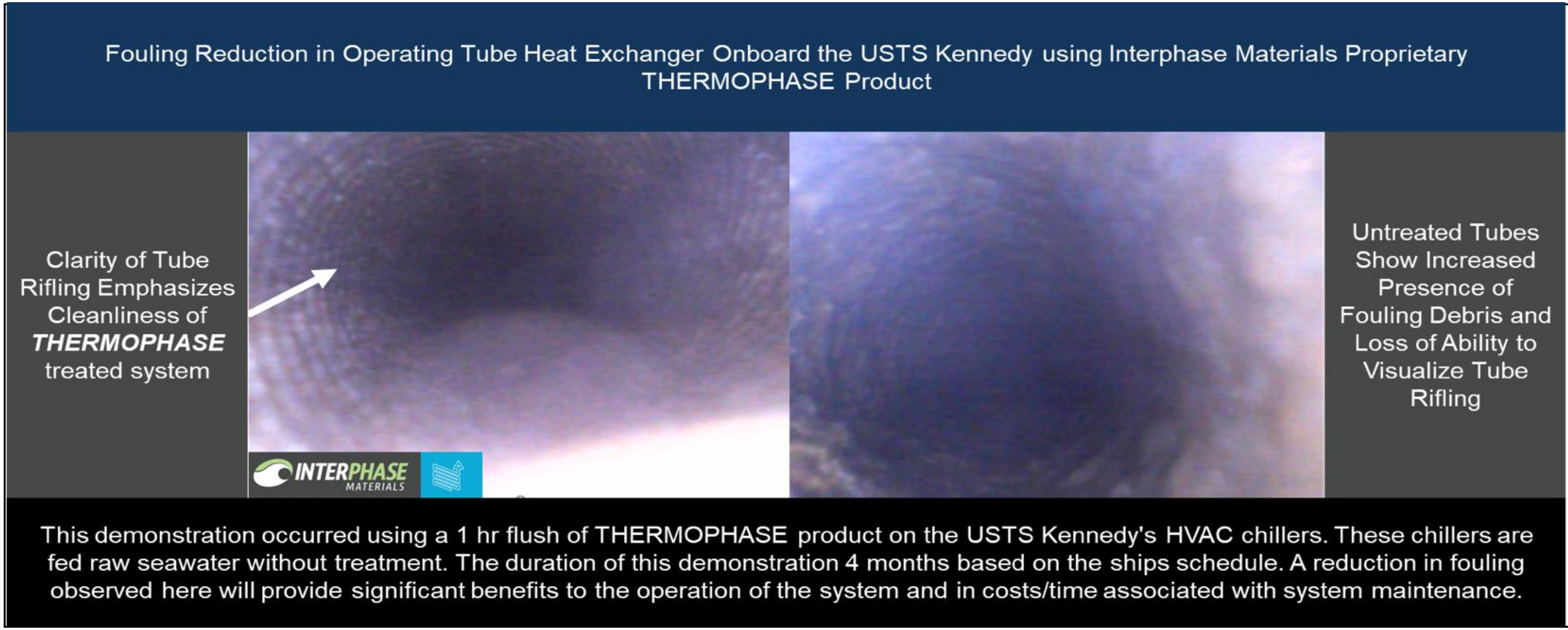
THERMOPHASE Reduces the Fouling Resistance (R_F) and Boundary Layer Resistance (R_B)

- Increase Power Plant Efficiency
- Backpressure Decrease
- Increase Condenser Heat Transfer
- Lower Boundary Layer and Fouling Thermal Resistances

THERMOPHASE is an advanced material technology applied to the inside of heat exchanger components, such as condenser tubes, to lower the thermal resistance of the material by reducing fouling and/or the boundary layer.

Fouling

THERMOPHASE On Operating Heat Exchanger - Chiller



THERMOPHASE reduced chiller tube fouling on the USTS Kennedy (DOT MARAD Project #693JF71850005, https://www.maritime.dot.gov/sites/marad.dot.gov/files/2022-09/Interphase%20Materials%20MMA%20Final%20Report.pdf).

UPMC Children's Hospital Chillers

Image 1: Borescope Image of Fouled Chiller Tubes from UPMC Children's Hospital Chiller in 2021

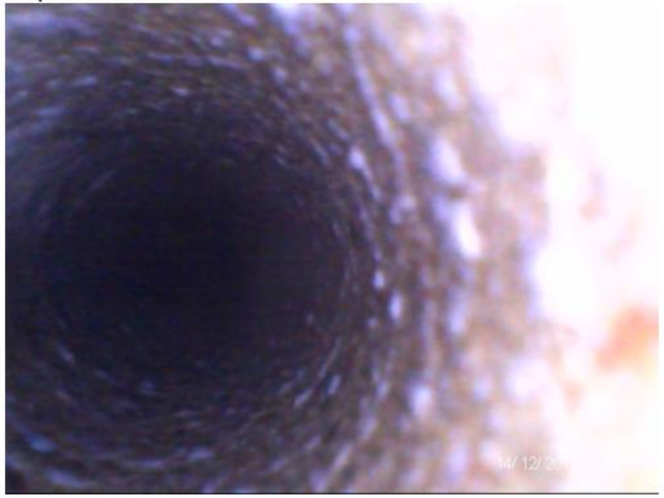


Image 2: Borescope Image of Chiller Tube After Cleaning from UPMC Children's Hospital Chiller in 2021

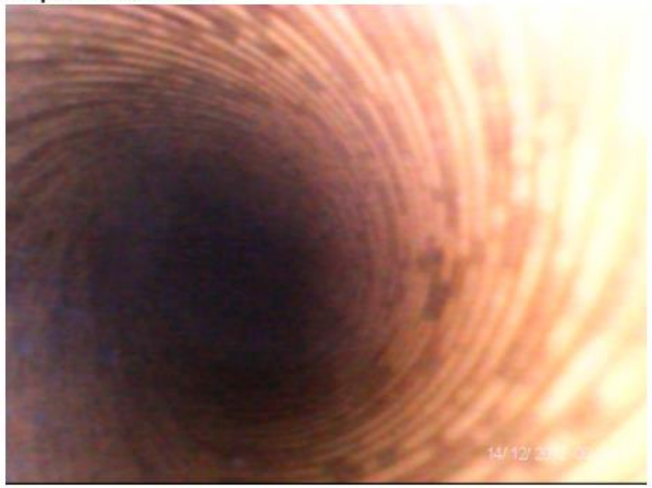


Image 3: Borescope Image of Chiller Tube 1 Year after THERMOPHASE application Without Cleaning in 2022

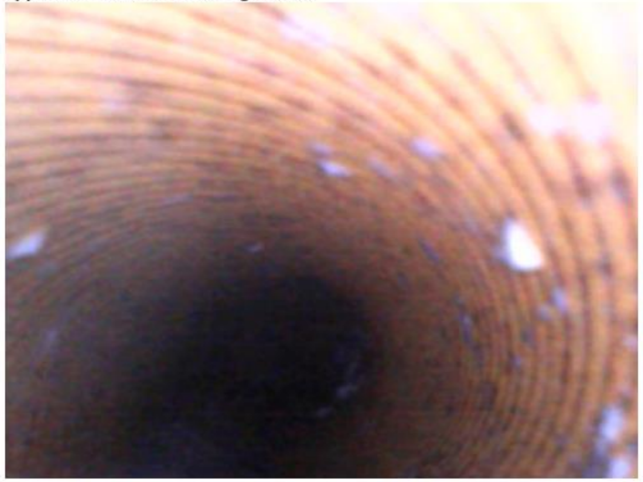
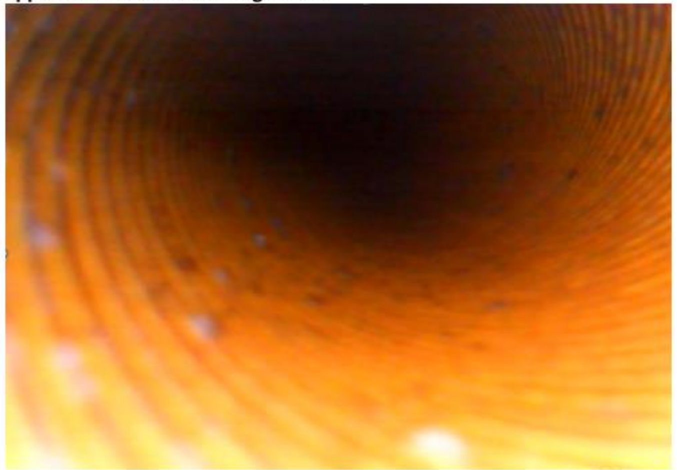


Image 4: Borescope Image of Chiller Tube 1 Year after THERMOPHASE application Without Cleaning in 2023



THERMOPHASE was applied by circulating it through the offline chiller. The chillers were treated between February and March of 2021. Without any cleaning, the chiller tubes were borescoped the following year in January/February 2022. This was duplicated in 2023 and tubes no longer clean the tubes. In 2024 inspection, with multiple years without cleaning and THERMOPHASE application the tubes remains clean. Yearly Eddy current testing by the plant is being moved to every 3 years.

Heat Transfer Improvements

Heat Transfer

THERMOPHASE

Heat Transfer Improvements have been excellent:

- Baseline lab results 5.8%
- 770MW results 4%
- 900MW results approximately 7% on condenser heat transfer coefficient and approximately 15% on heat exchangers effectiveness
- EPRI test results on new tubes 2.4% and increasing before test ended

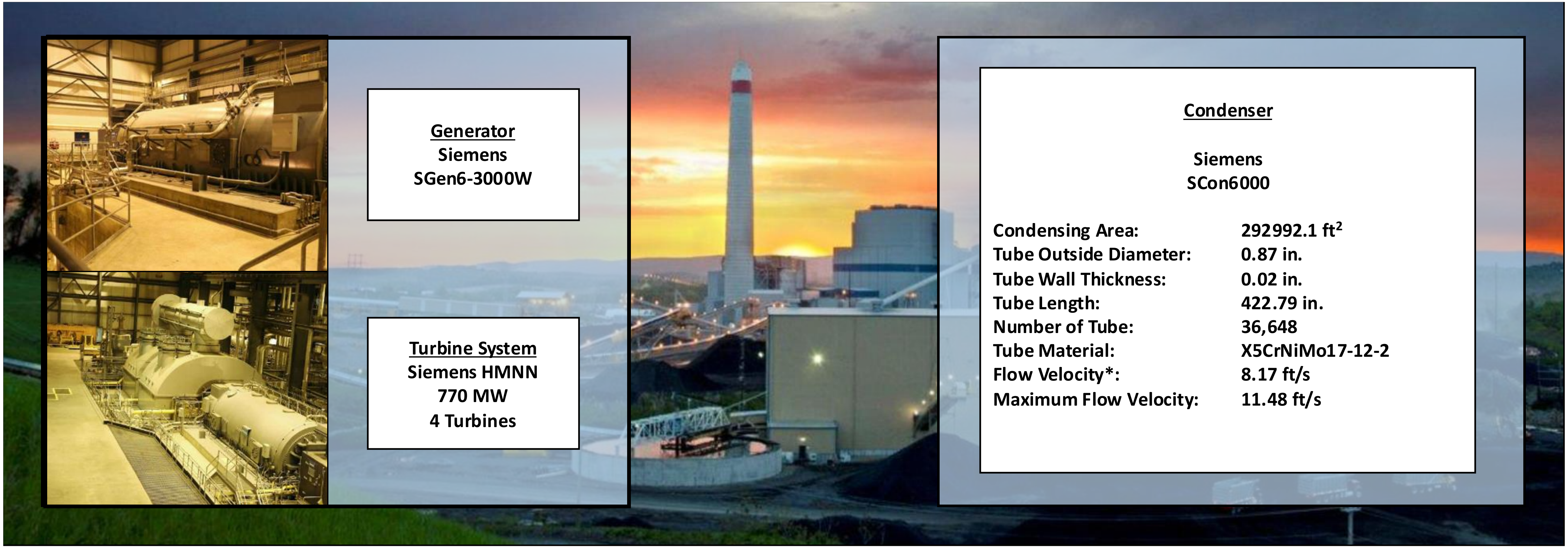
Electric Power Research Institute (EPRI) Validation

- Interphase Materials was asked by the Electric Power Research Institute (EPRI) to include samples of THERMOPHASE in a project to evaluate coatings for condenser tubes.
- During the first phase of testing, THERMOPHASE was ranked the highest compared to 5 other coatings being evaluated on a basis of hydrophobicity (ASTM D7334), thermal conductivity (ASTM E1461), adhesion (ASTM C1624), and abrasion (ASTM G133) testing.
- THERMOPHASE was shown to increase the heat transfer coefficient by 1.8% when compared to clean, unmodified tubes. Over a month later, the improvement increased to 2.4% and was improving when test was stopped. The test was a short duration and THERMOPHASE was the only internal coating that showed improvement during the test time frame.
- Data is consistent with the DOE/NETL two year program at Longview and other installations of THERMOPHASE

Full Scale Power Plants

THERMOPHASE Application at Longview Power

Longview Power Plant Overview



Generator
Siemens
SGen6-3000W

Turbine System
Siemens HMNN
770 MW
4 Turbines

Condenser

Siemens
SCon6000

Condensing Area:	**292992.1 ft^2**
Tube Outside Diameter:	**0.87 in.**
Tube Wall Thickness:	**0.02 in.**
Tube Length:	**422.79 in.**
Number of Tube:	**36,648**
Tube Material:	**X5CrNiMo17-12-2**
Flow Velocity*:	**8.17 ft/s**
Maximum Flow Velocity:	**11.48 ft/s**

*Flow velocity at rated temperature rise

Source: The Future of Reliable Clean Coal Power. Retrieved December 13, 2022, from https://longviewpower.com/clean-coal-power

THERMOPHASE Application at Longview Power

THERMOPHASE Applications

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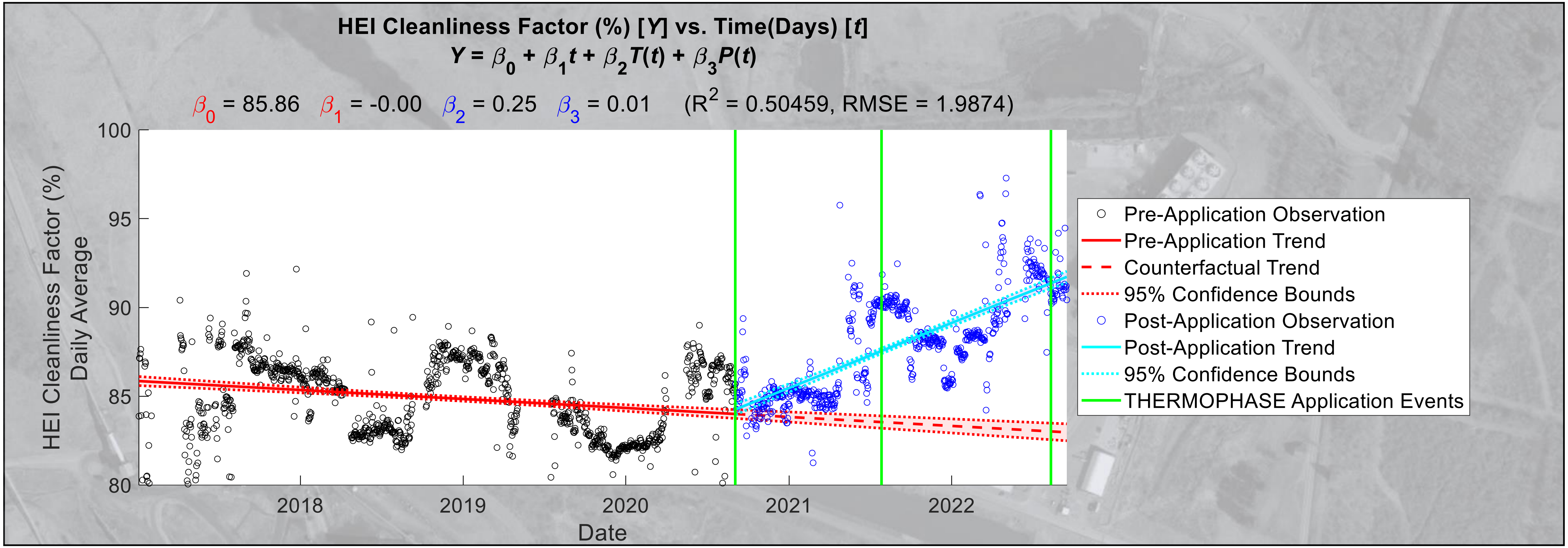
Application 1 on September 2nd, 2020

Application 2 on July 27th, 2021

THERMOPHASE was applied to the Longview Power plant beginning on September 2nd, 2020. The second and third applications were on July 27th, 2021, and August 11th, 2022. In the first application, THERMOPHASE was slowly added over two weeks. The second and third applications were performed by adding the material directly into the cooling tower sump.. The tubes of the condenser were not cleaned before or after THERMOPHASE application.

THERMOPHASE Application at Longview Power

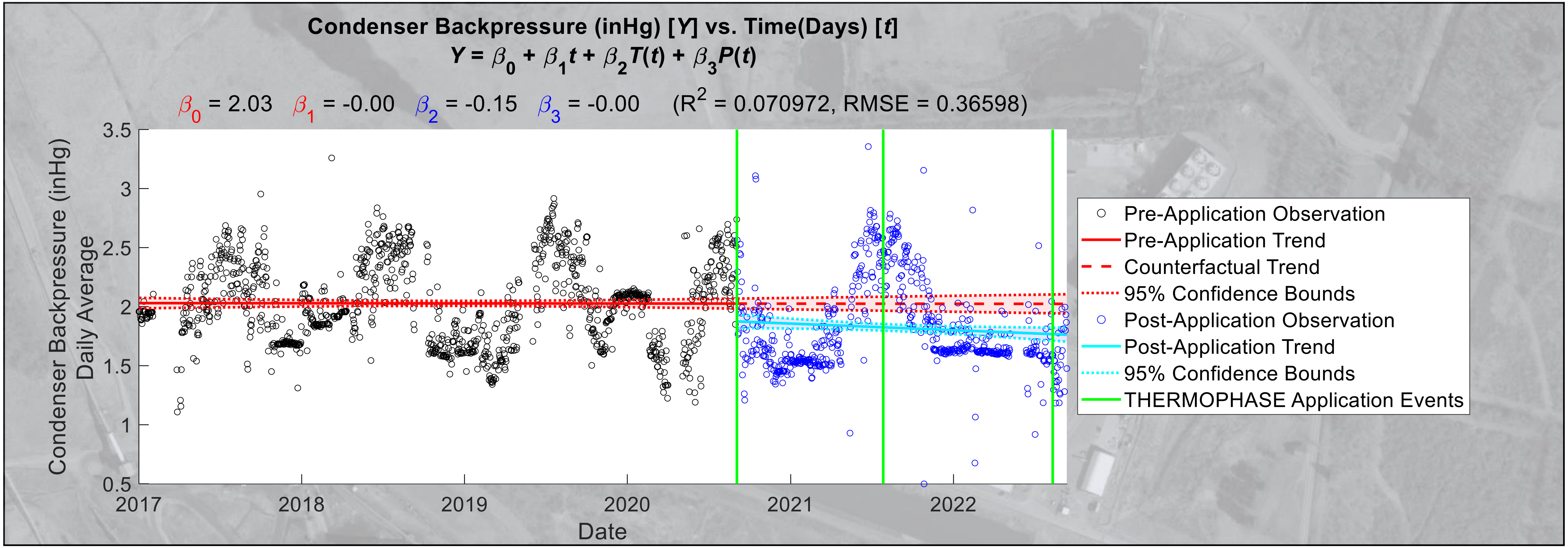
HEI Cleanliness Factor



The daily average of the HEI Cleanliness Factor is plotted above through September 16th, 2022. The HEI Cleanliness Factor is a historian calculation recorded in the Longview Power historian (variable 1OPM.CONDENSER:Cleanliness). The HEI Cleanliness Factor is defined as $\frac{U_{Observed}}{U_{Expected}} \times 100.$

THERMOPHASE Application at Longview Power

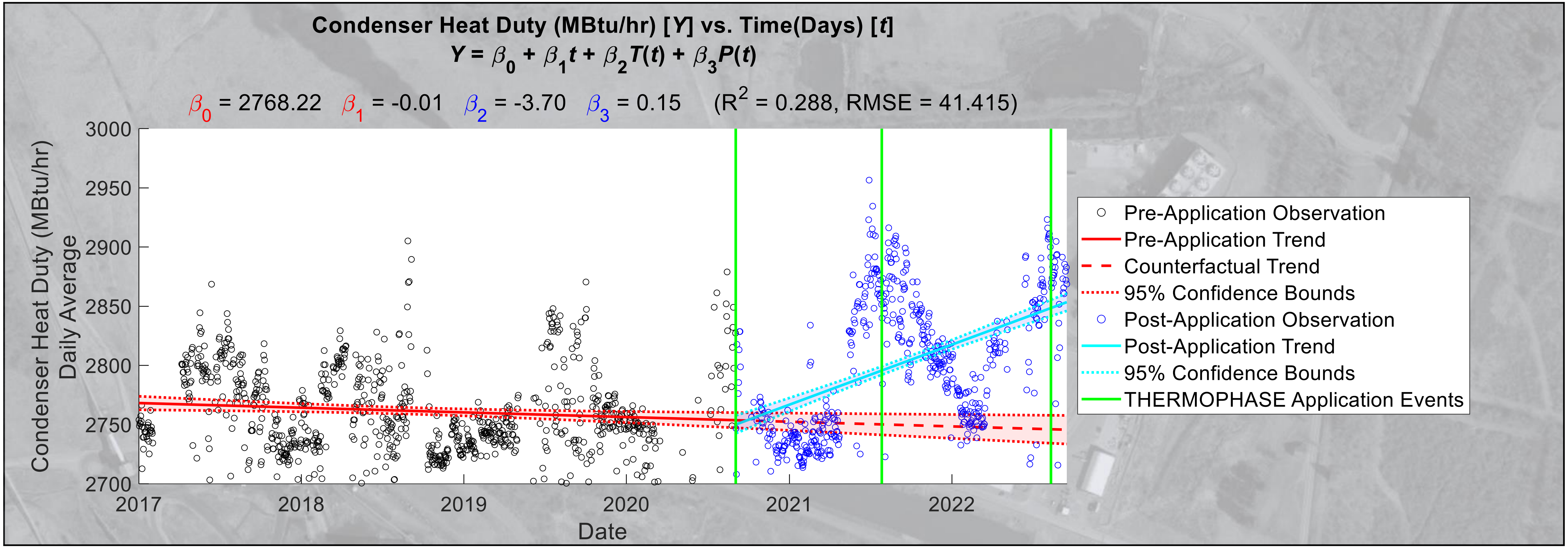
Condenser Backpressure



The daily average of the condenser backpressure is plotted above through September 16th, 2022. The condenser backpressure is an instrument value recorded in the Longview Power historian (variable 10MAG10CP002.XQ01).

THERMOPHASE Application at Longview Power

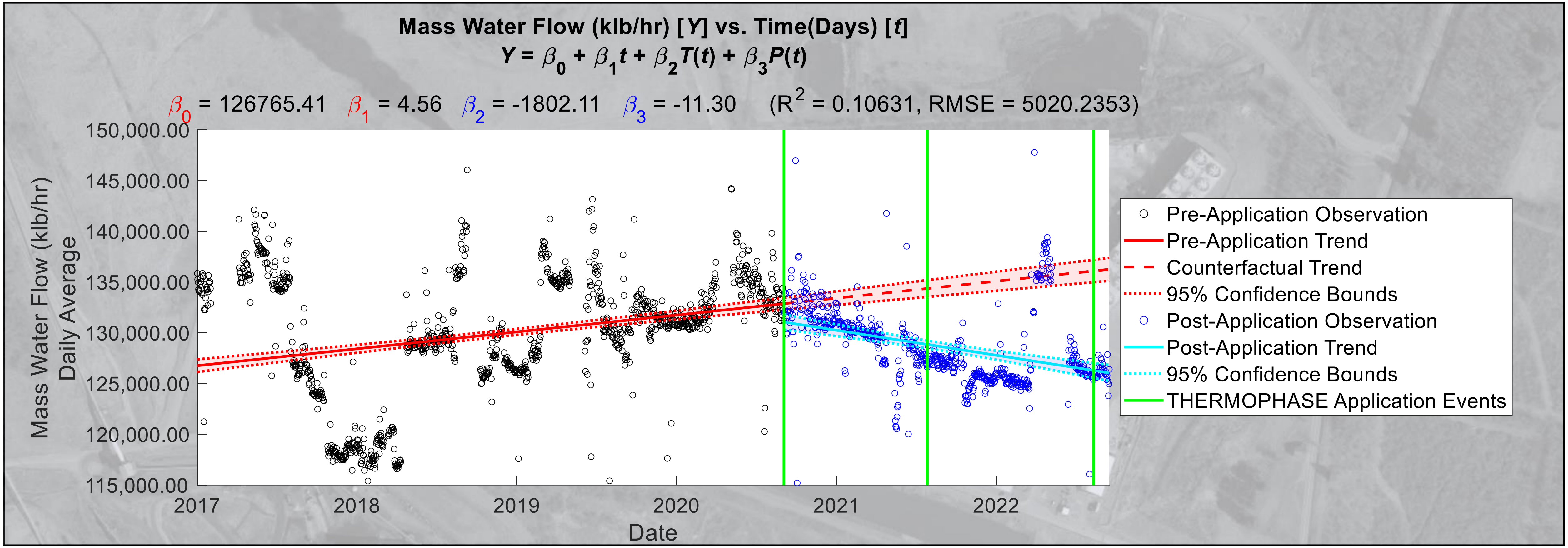
Condenser Heat Duty



The daily average of the condenser heat duty is plotted above through September 16th, 2022. The condenser heat duty is an historical calculation recorded in the Longview Power historian (variable 1OPM.CONDENSER:DUTY).

THERMOPHASE Application at Longview Power

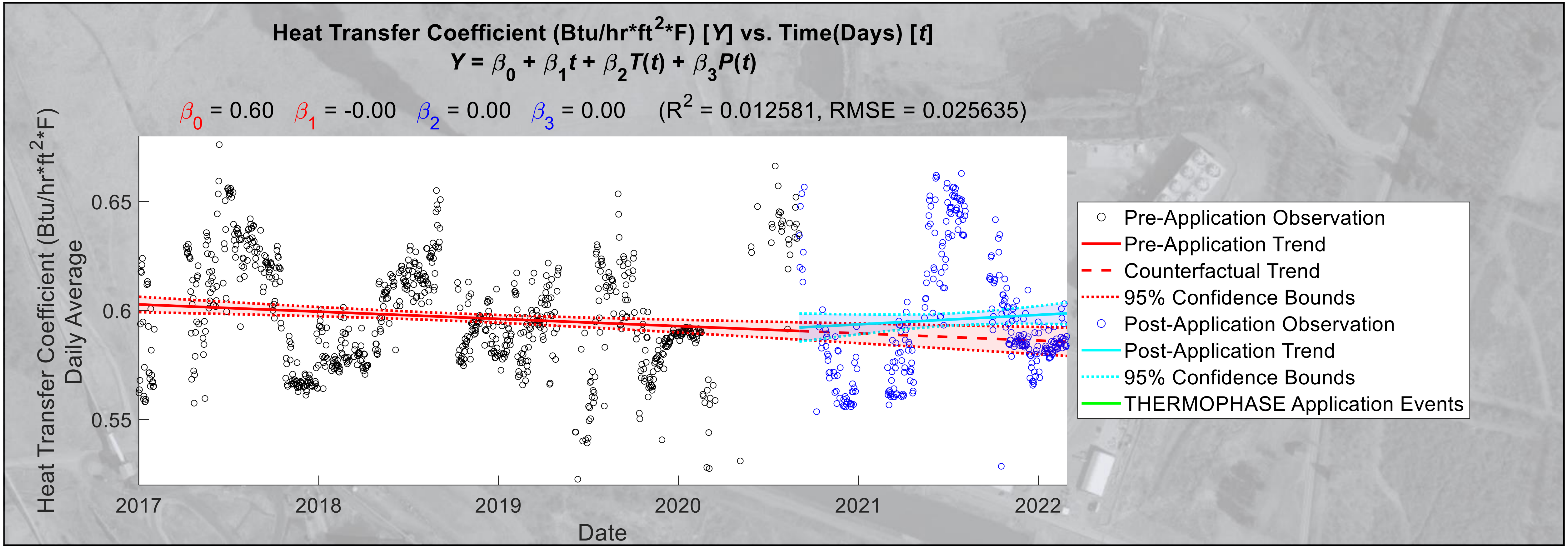
Water Flow



The daily average of the mass circulation water flow is plotted above through September 16th, 2022. The mass circulation water flow is a historian calculated value recorded in the Longview Power historian (variable 1OPM.CIRC_WATER_IN:FLOW).

THERMOPHASE Application at Longview Power

Heat Transfer Coefficient



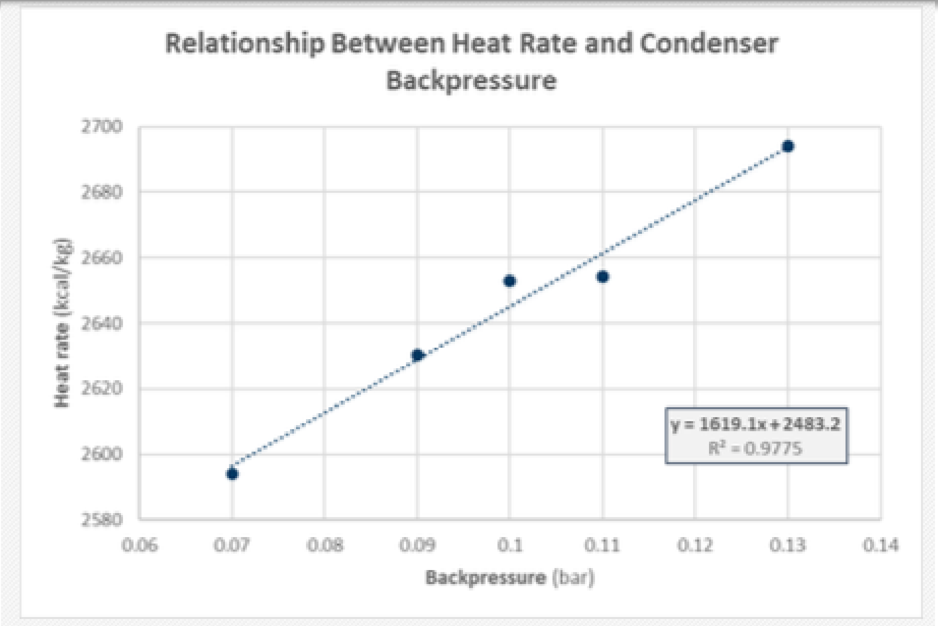
The daily average of the heat transfer coefficient is plotted above through September 12th, 2022. The heat transfer coefficient is an offline calculation. The heat transfer coefficient (U) is defined as, $U = \frac{Q}{A \cdot LMTD}$.

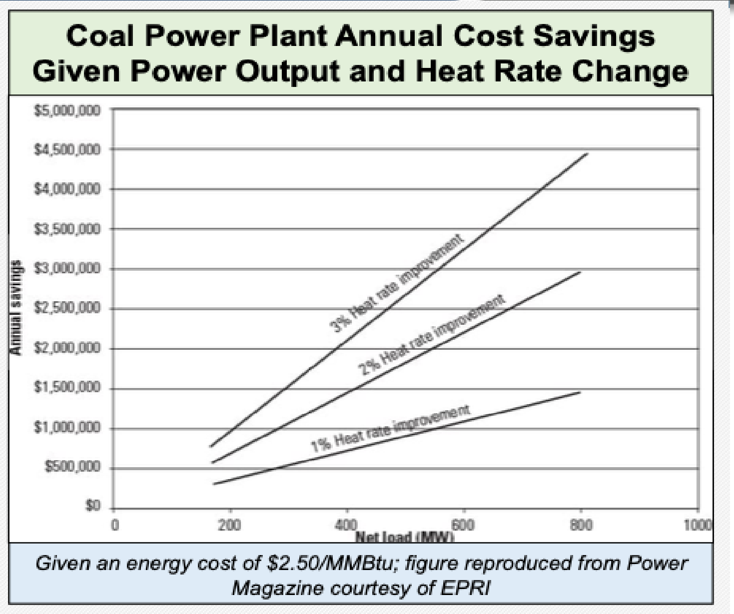
Data From Over 2 Years Validates THERMOPHASE

Data provided to DOE/NETL and presented that validates THERMOPHASE Benefits include:

- HEI Cleanliness Factor
- Condenser Backpressure
- Terminal Temperature Difference
- Condenser Heat Duty
- Temperature Rise
- Log-Mean Temperature Difference
- Heat Transfer Coefficient
- Water Flow
- Condenser Water Outlet Temperature
- Condenser Water Inlet Temperature
- Wet Bulb Temperature/Dry Bulb Temperature
- Cooling Tower Approach Temperature

Longview Power Plant - Operational Savings (Partial List)





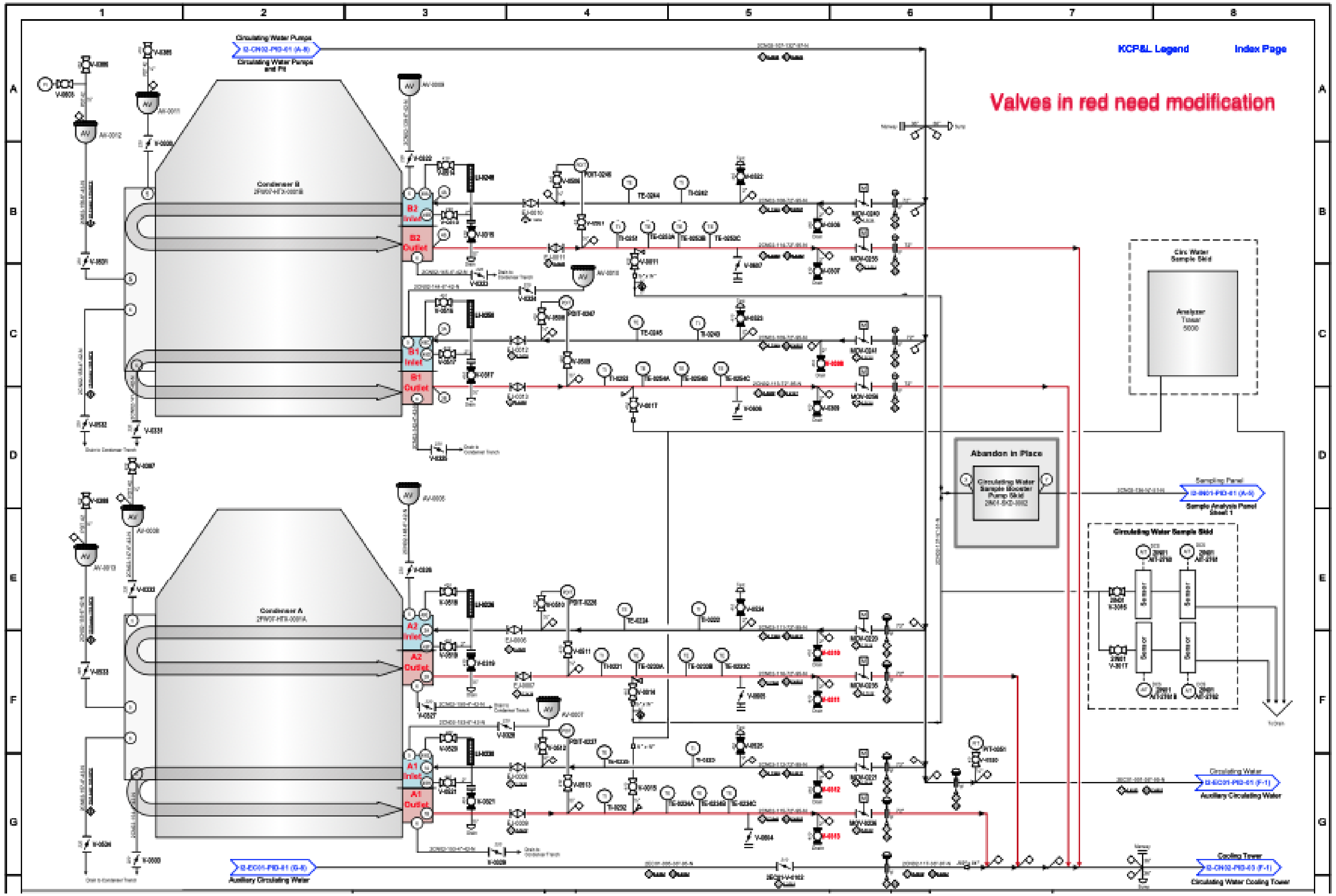
THERMOPHASE 24-Month Savings

Savings Type	Longview Power Plant
Water Withdrawl	1,287 ± 750.8 Mgal
CO_2 Emissions	136 ± 79.3 Mlbs
Fuel Cost (in Millions)	$3.35 ± 1.68

- Heat Transfer Coefficient Improvements at Longview (4%) were consistent with laboratory results (5.8%)
- Immediate and Sustained Backpressure improvements are consistent with condenser performance improvements (TTD, U, and HEI CF%)
- Based on a net decrease of 0.26 inHg after two years (13% reduction), the water, emissions, and fuel cost savings are significant and in support of the DOE/NETLs mission to provide solutions for an environmentally sustainable and prosperous energy future

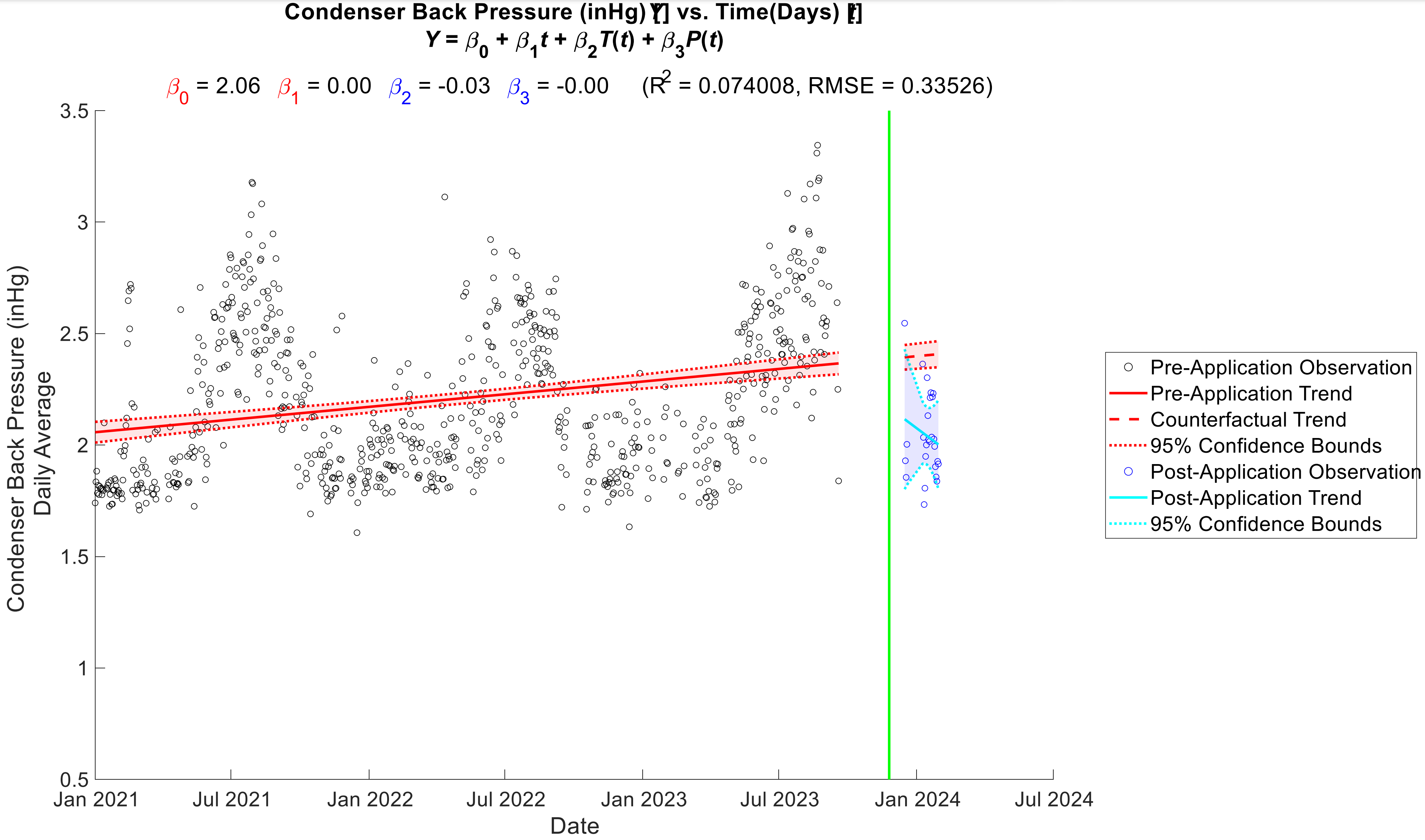
900MW Unit

900MW Unit
Condenser P&ID



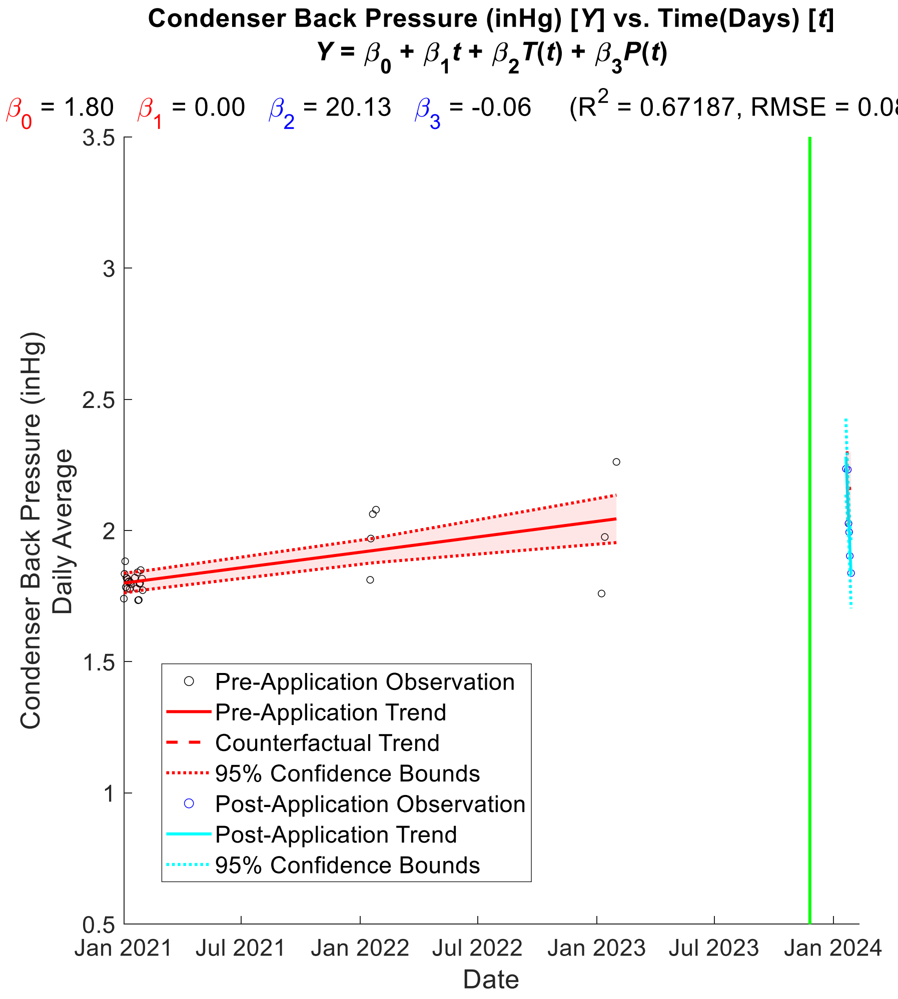
900MW Unit

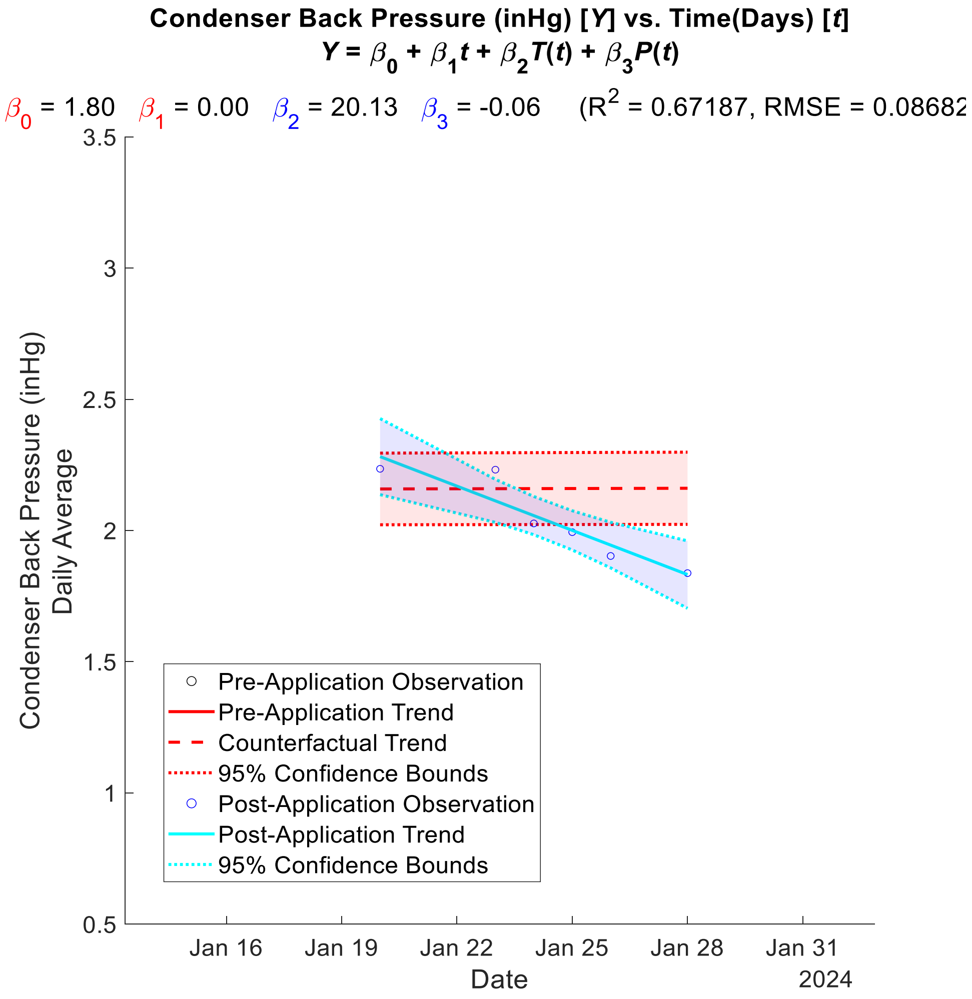
Condenser Analysis – Back Pressure



900MW Unit

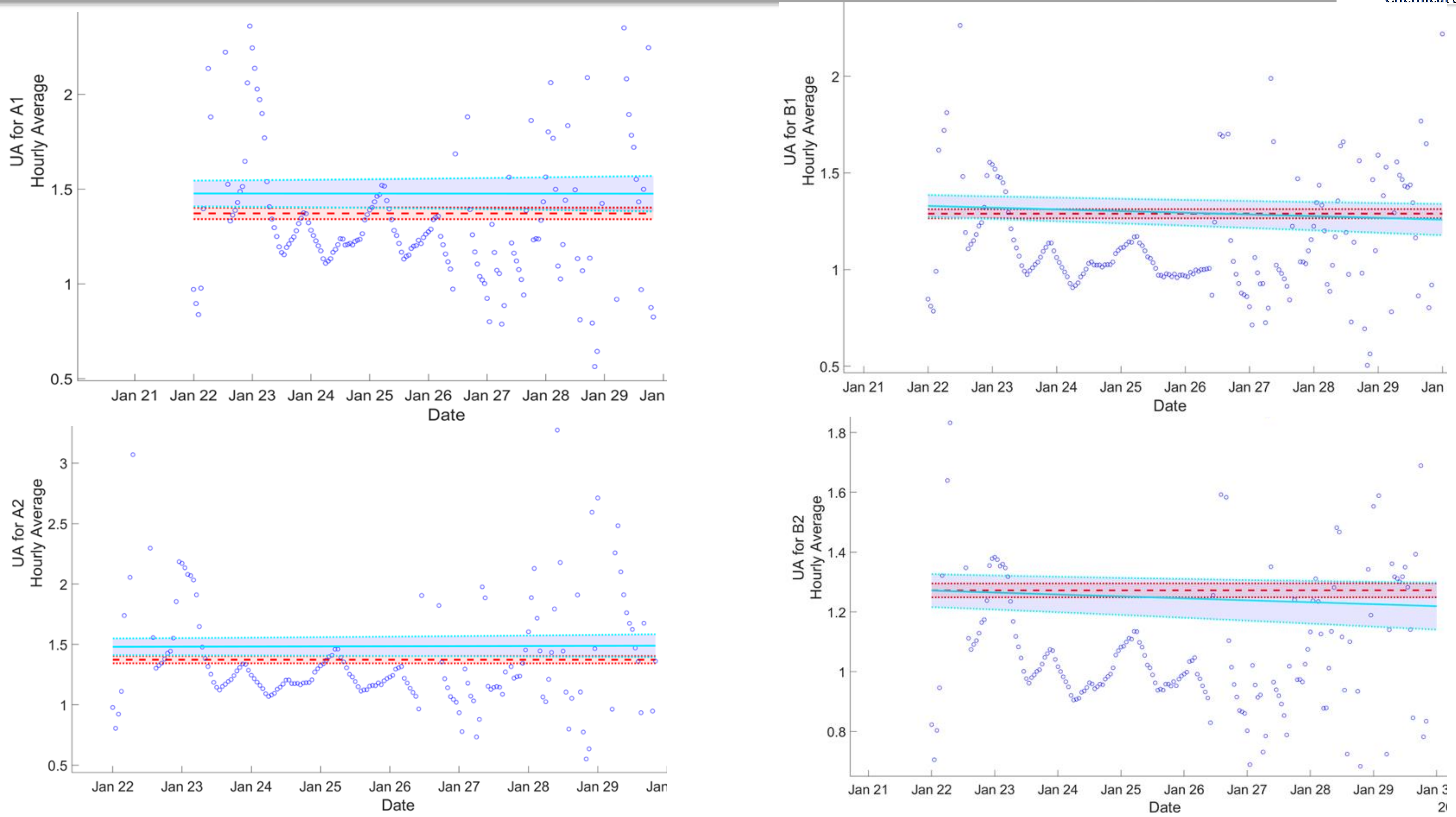
Condenser Analysis – Back Pressure (January Daily)





900MW Unit

Condenser Heat Transfer Coefficient (THERMOPHASE Treated vs Untreated)



900MW Unit

Condenser Analysis – Back Pressure – 4 Year June Monthly Comparison

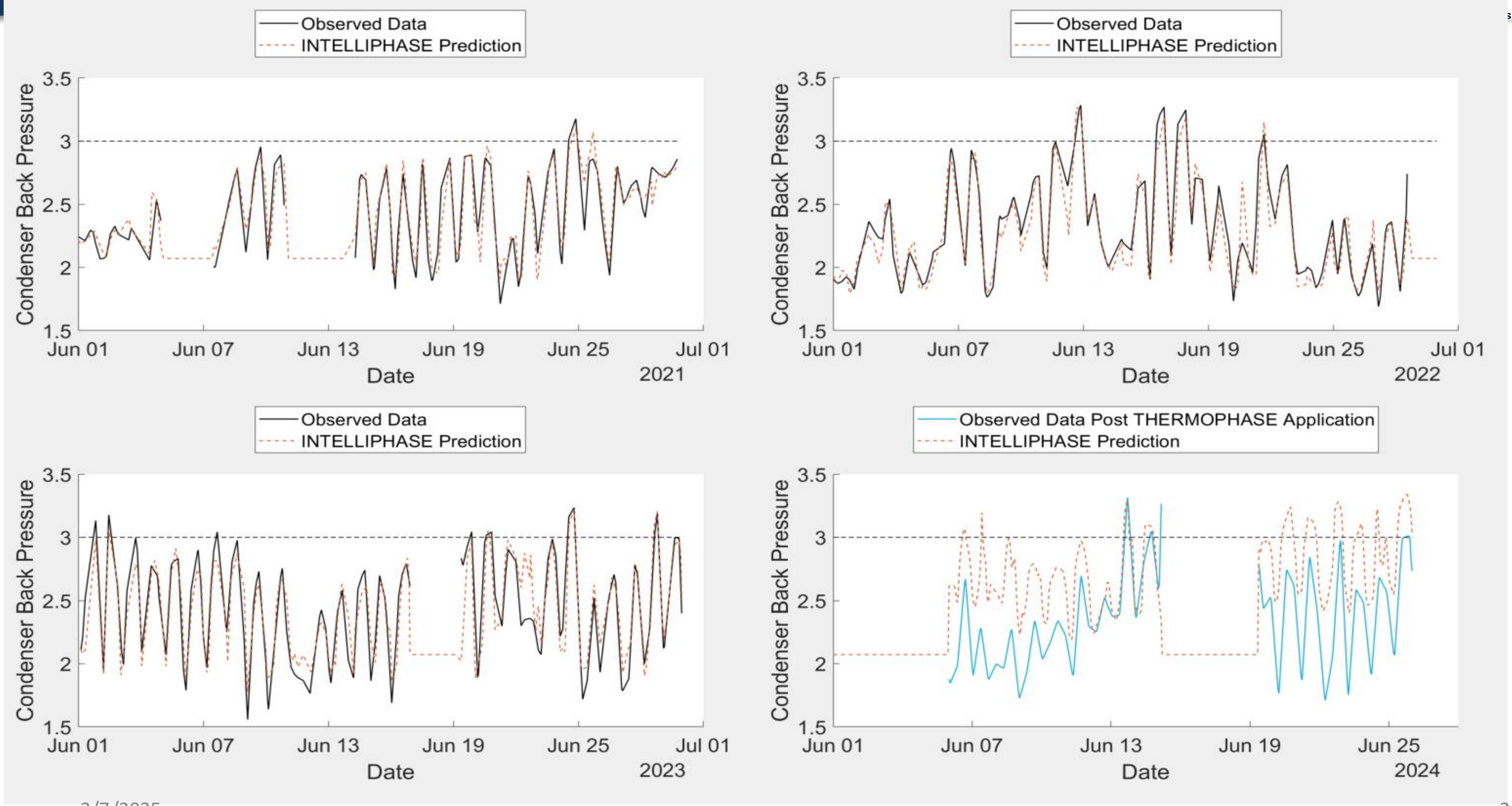
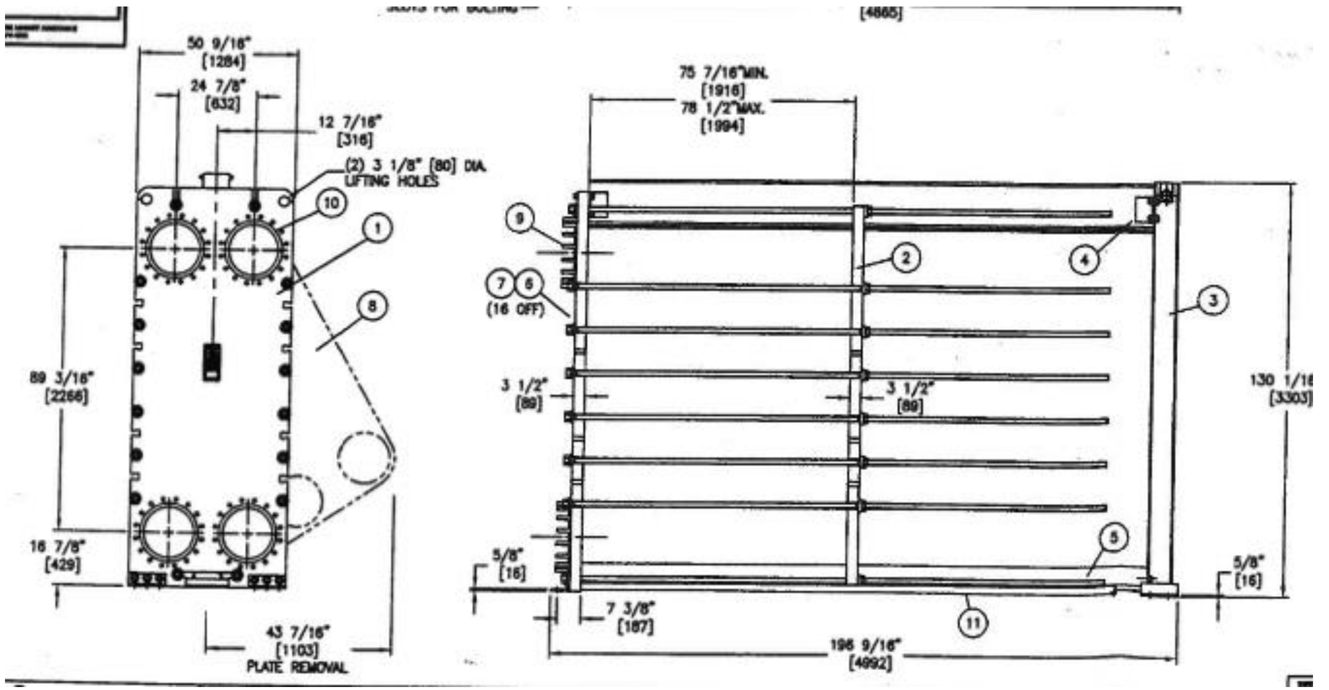


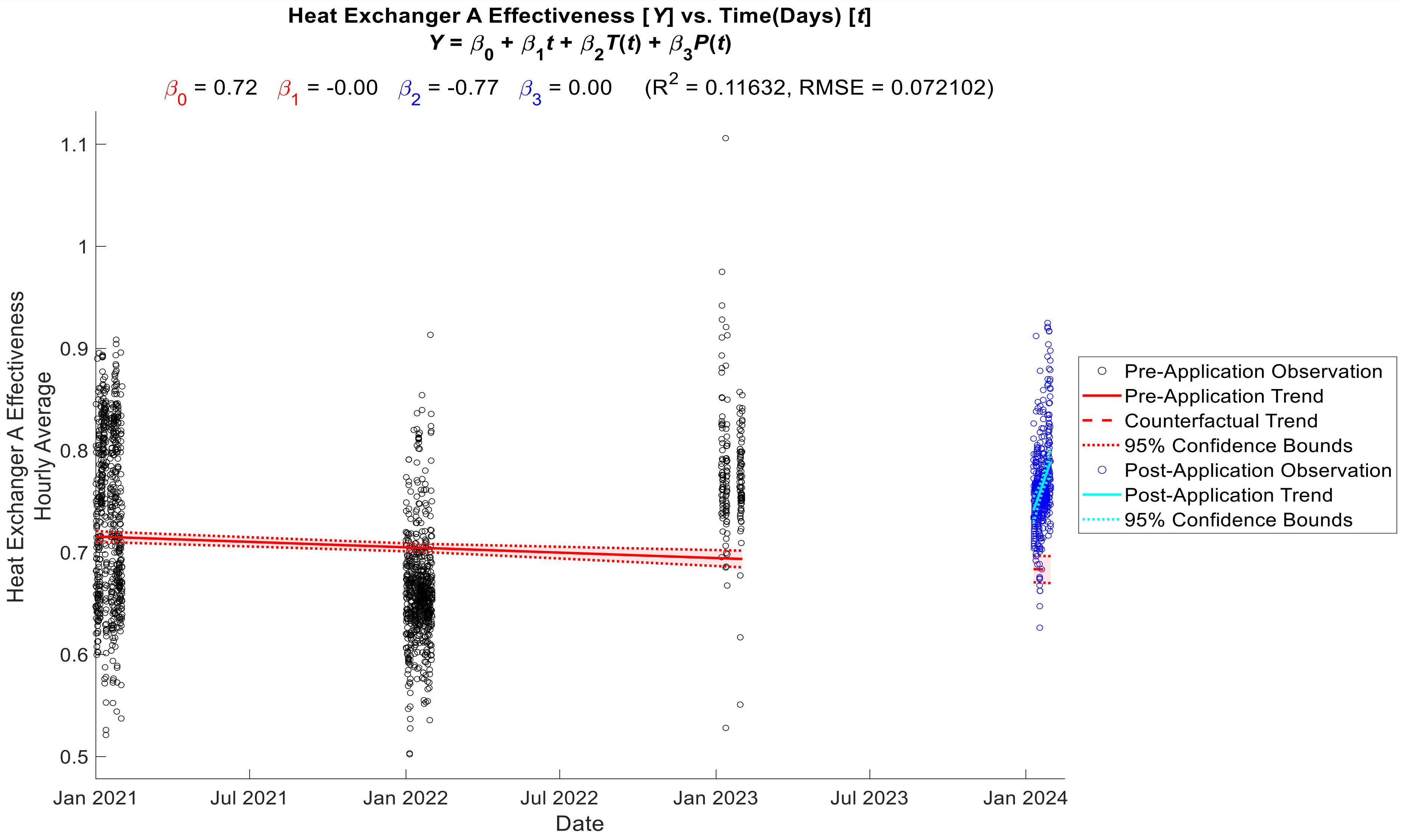
Plate & Frame Heat Exchangers
900MW Unit

CCW Plate & Frame Heat Exchangers (900MW Unit)



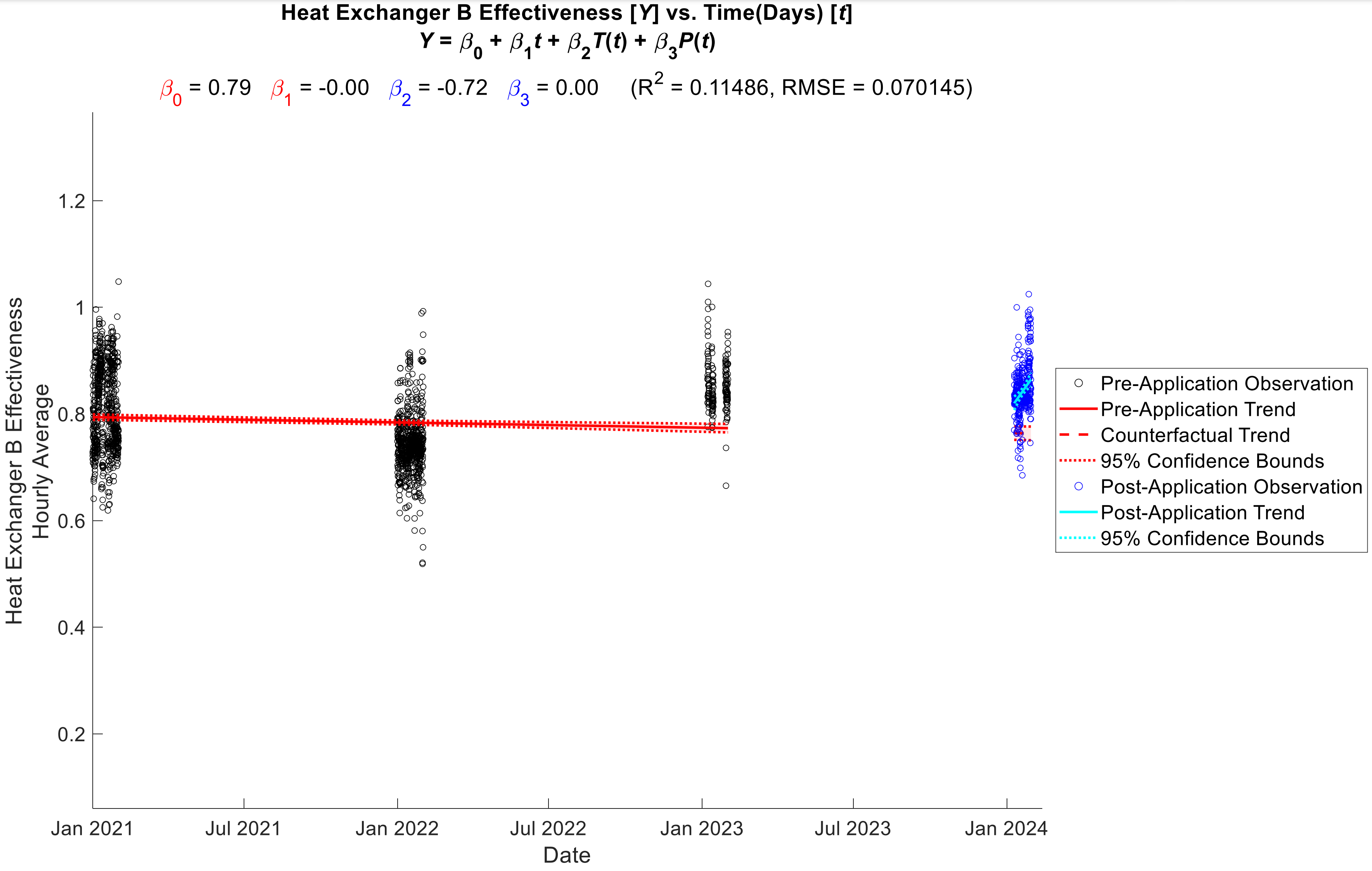
CCW Plate & Frame Heat Exchangers (900MW Unit)

Heat Exchanger A Effectiveness



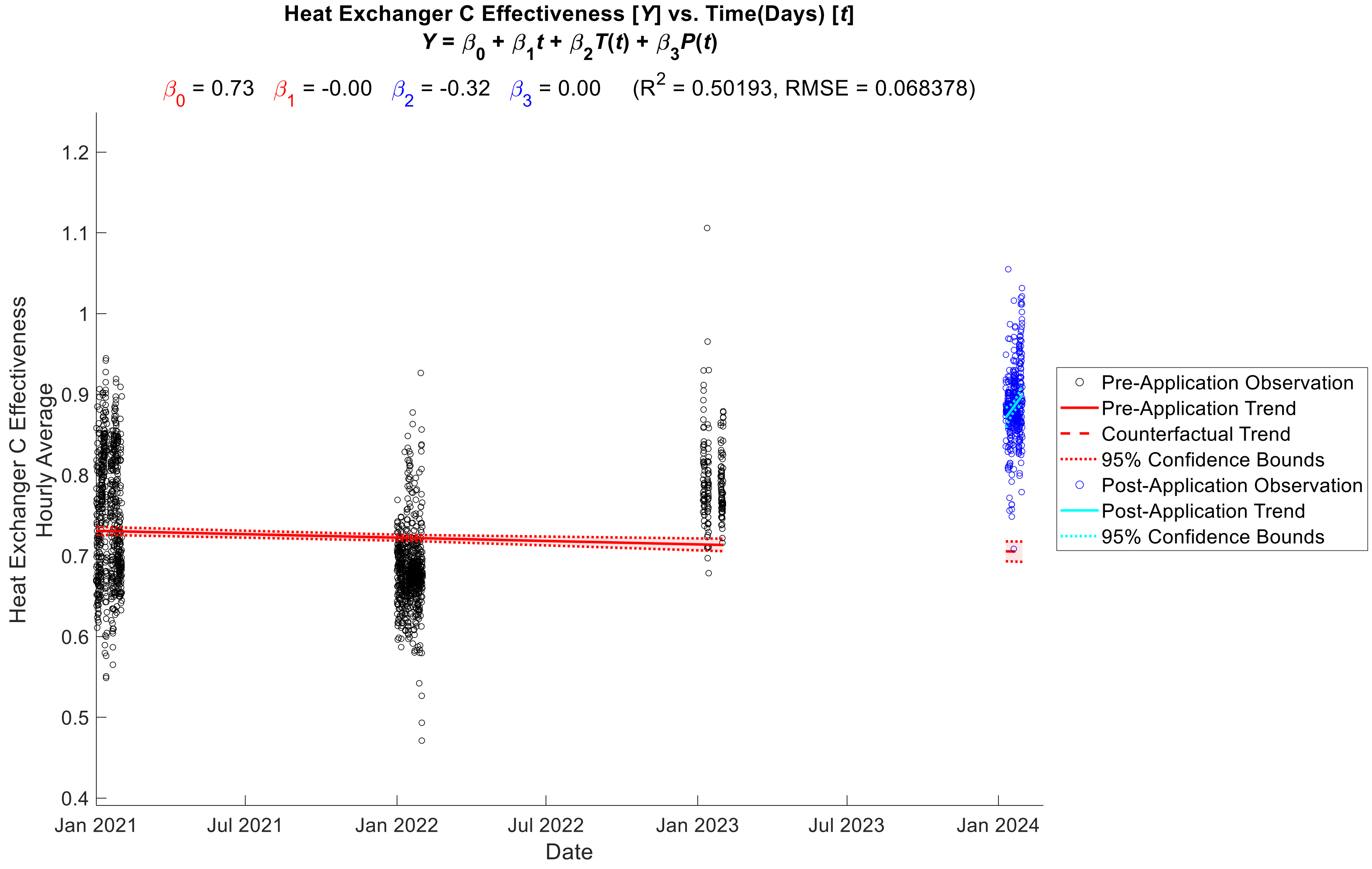
CCW Plate & Frame Heat Exchangers (900MW Unit)

Heat Exchanger B Effectiveness



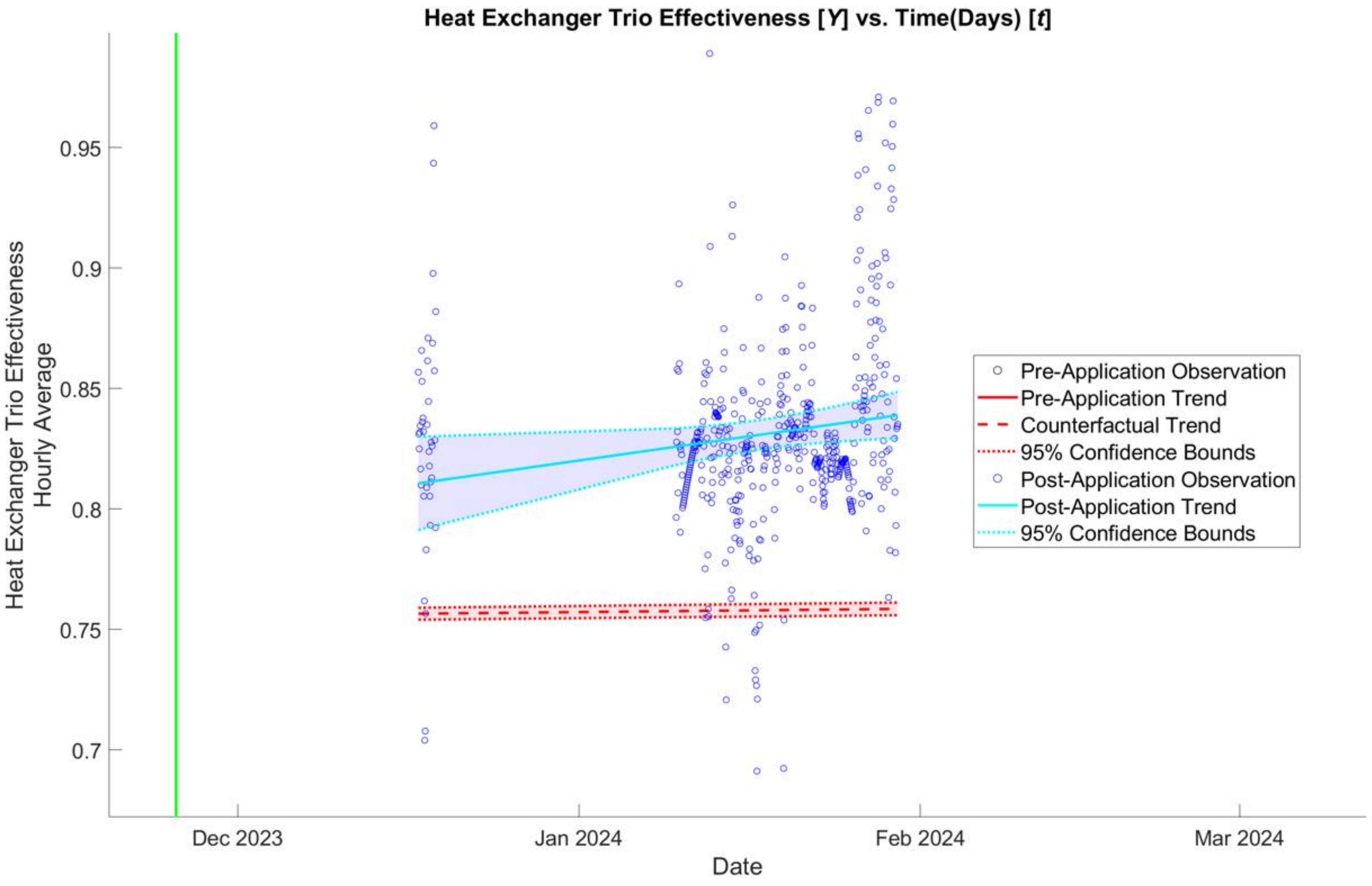
CCW Plate & Frame Heat Exchangers (900MW Unit)

Heat Exchanger C Effectiveness



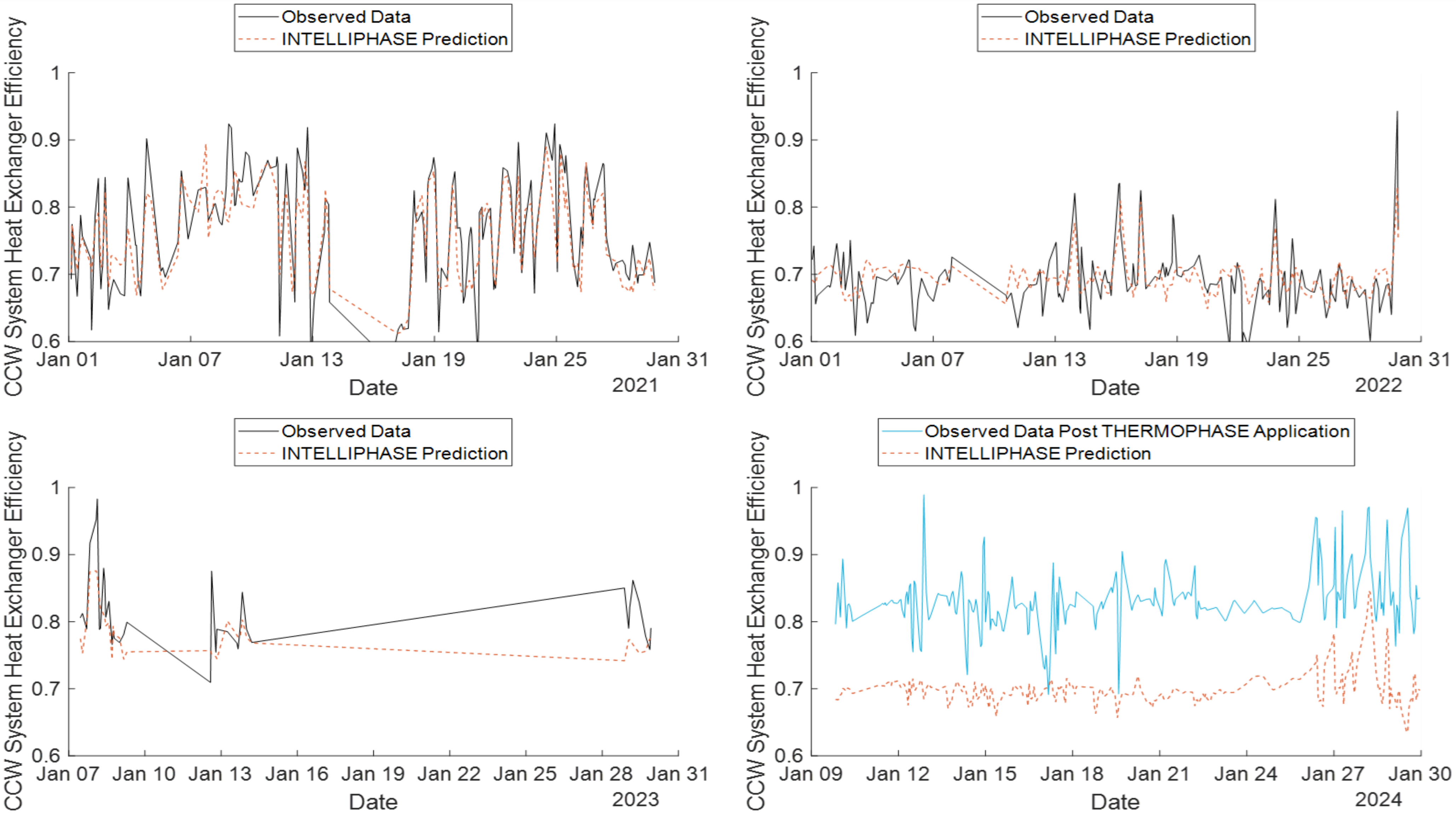
CCW Plate & Frame Heat Exchangers (900MW Unit)

Total Combined Heat Exchangers Effectiveness



CCW Plate & Frame Heat Exchangers (900MW Unit)

Total Combined Heat Exchangers Effectiveness – 4 Year January Monthly Comparison



CCW Plate & Frame Heat Exchangers (900MW Unit)

Total Combined Heat Exchangers Effectiveness – 4 Year June Monthly Comparison

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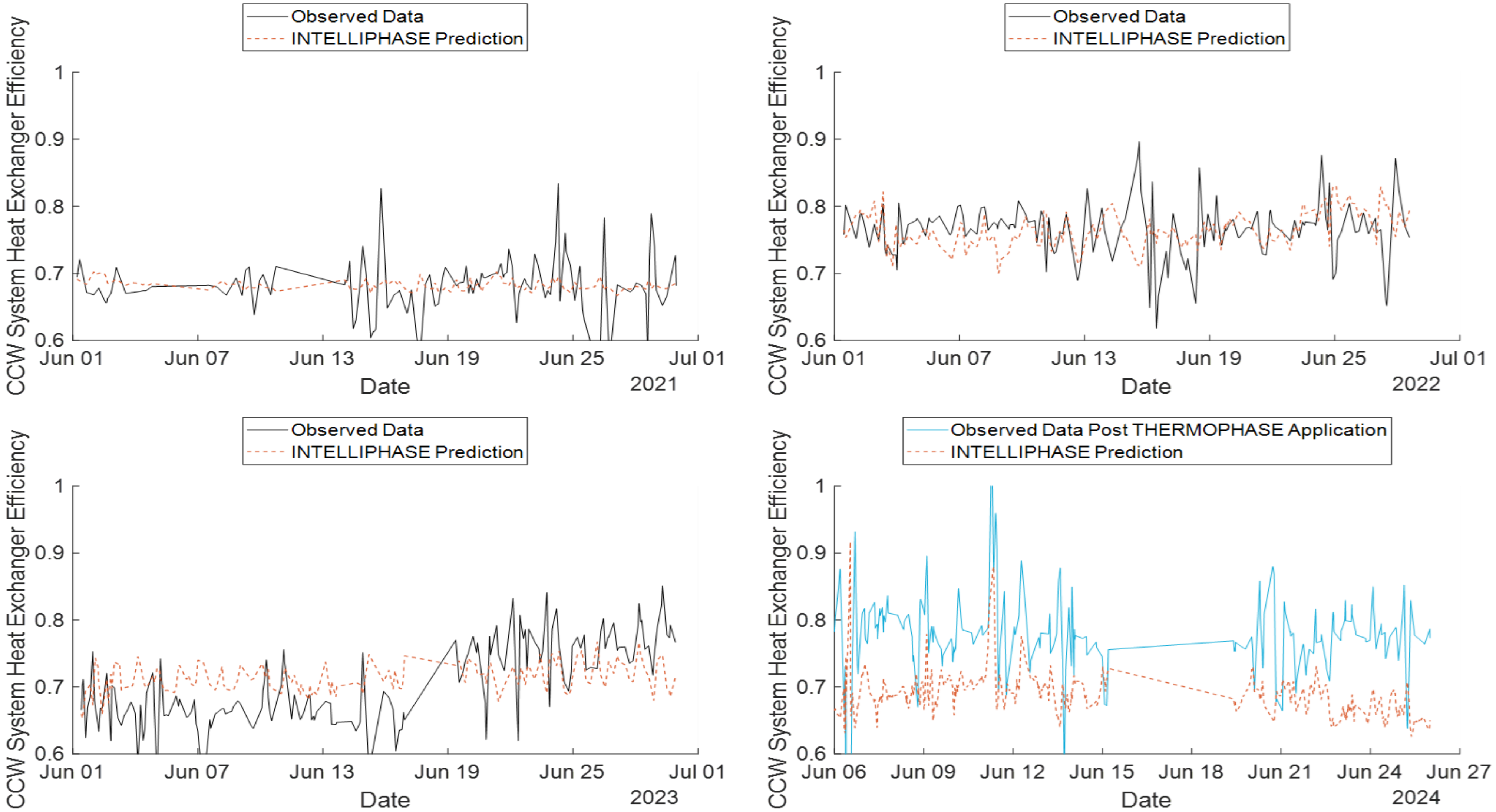

Cooling Towers

THERMOPHASE Application at Longview Power

THERMOPHASE Cooling Tower Fill Fouling Reduction

THERMOPHASE treatment reduced dry weight by 18%. Small-scale cooling towers installed at water treatment station, circulating raw untreated water over the 2019 fouling season. Towers treated with THERMOPHASE showed increased fouling resistance, accumulating 18% less dry weight fouling.

Entity Validation of THERMOPHASE

- United States Department of Energy (DOE)
- National Energy Technology Labs (NETL)
- Electric Power Research Institute (EPRI)
- U.S. Department of Transportation Maritime Administration (MARAD)
- United States Navy

THERMOPHASE has been demonstrated on marine engines, chillers, heat exchangers, and condensers. Recent tests show effective on membrane filters and this is being developed.

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THANK YOU!